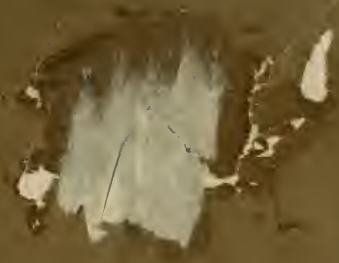
CROUP

IN ITS

RELATIONS TO TRACHEOTOMY.



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CROUP,

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RELATIONS TO TRACHEOTOMY.

BY

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This essay was read before the Philadelphia County Medical Society, January 14, 1874; referred by that Society to the Medical Society of the State of Pennsylvania; and by the latter Society, ordered to be printed in their Transactions for the current year. It is based on a careful study of the published records of more than five thousand cases of Tracheotomy in Croup, performed in various portions of the world.

CROUP,

IN ITS

RELATIONS TO TRACHEOTOMY.

By Croup I mean *exudative inflammation of the air-passages.* Its relations to tracheotomy, as portrayed in this paper, include *sthenic croup*, or croup proper, and *systemic croup*, or the croup of diphtheria; but take no cognizance of *traumatic croup*, or that variety of exudative inflammation which ensues on the contact of ammonia, hydrochloric acid, and other vesicants. These three species of croup have one manifestation in common: the deposition of a pseudo-membrane, which appears to be identical physically, chemically, and microscopically.

The demand for aid to respiration is as urgent in diphtheritic as in sthenic croup; though, for obvious reasons, the ultimate success from an operation cannot be as great.

Tracheotomy for croup is generally regarded with much disfavor in this city. Its results in Philadelphia have been less encouraging than almost anywhere else; probably because, as a rule, the operation is postponed too long; possibly because our medicinal treatment of croup cures a number of cases which, under less efficient management, would become subjects for tracheotomy; but, whatever the cause, the results, in the comparatively few instances in which the operation has been performed, have been so disheartening, that many practitioners refuse to sanction tracheotomy in croup under any circumstances. This radical feeling is wrong. Not only should our individual experience be utilized in judgment, but the recorded experience of others also. Early failures may be followed by ultimate successes.

Barthez, in a letter to Rilliet[1] on the comparative results of the treatment of croup by tracheotomy and by medication during the years 1854–1858,

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[1] Gaz. hebd., Dec. 2, 1859; Brit and For. Med.-Chir. Rev., April, 1860; Am. Journ. Med. Sci., July, 1860.

stated that the first year the Hôpital Sainte-Eugènie was opened, 13 croup patients were submitted to tracheotomy, of whom the first died during the operation, and 11 others in succession after the operation; the first recovery taking place in the thirteenth case. Yet Barthez had many successes afterwards; for in a letter published in 1868,[1] he stated that in the same hospital, between the years 1861–1867, 785 cases were operated upon, with 222 recoveries. Guersant lost his first 23 cases, between 1834–1841; but after that saved 17 out of 82.[2] Trousseau, up to 1842, had operated 119 times, with but 25 recoveries; but at a later date (1854) he reported 222 operations with 127 recoveries.[3] Similar examples of early want of success followed by results truly gratifying are on record. But there have been results even worse than these. Thus Trousseau, in a discussion on tracheotomy in croup, before the Academy of Medicine, in 1858, mentioned,[4] that in the earlier days of the operation, Gosselin, Deguise, Huguier, Jarjavay, and Monod, Jr., of Paris, performed 95 operations successively without a single recovery; that Alphonse Guérin, Michon, Laugier, Robert, Nélaton, Lenoir, and Depaul saved but 11 cases out of 117 operations; and Velpeau, Jobert, and Desormeaux but 16 out of 84. He attributed much of this want of success to the idea then prevalent that the surgeon's duty ended when he had opened the trachea.

That tracheotomy saves many croup-patients from death otherwise inevitable, and that, too, even under unfavorable circumstances, there has long been no reason to doubt: there is little doubt, either, that patients are occasionally tracheotomized unnecessarily; but the proportionately small number of such instances, whether errors of judgment or errors of prudence, is, in all probability, insignificant in comparison with the number of patients saved by the operation from certain death; life being preserved in the one instance, while it is not sacrificed in the other.

Tracheotomy, in itself, does not cure croup. It affords a possibility of recovery by postponing, or insures it by averting death. The course of the disease is continued until all its attendant phenomena have undergone evolution. The surgeon's knife merely cuts a path for air to reach the bronchi in quantity sufficient for the requirements of the respiratory process, and saves the muscular force, exhausted in futile efforts at respiration through the glottis. Is it not possible that the freedom of breathing, and consequent

[1] Gaz. méd. de Paris, 1868, p 449: in reply to a statement of Vacher.

[2] Bouvier; Bull. Acad. de méd., xxiv., 1858-9, pp. 188 and 192. In his Chirurgie des Enfants, Paris, 1864-7, Guersant says he saved but 2 out of his first 33 cases. Friedreich, in Virchow's Handbuch der speciellen Pathologie und Therapie; Erlangen, 1858, Bd. v., states that Guersant saved 31 out of 91 cases operated on in hospital and private practice.

[3] Friedreich, op. cit., p. 454.

[4] Bull. Acad. de méd., xxiv., 1858-9, p. 230.

conservation of strength, would aid the system to resist the full effects of the development of the disease, in the further production of exudation, or its plastic deposition upon the bronchial mucous membrane? Then the artificial opening affords a better means of escape for the false membrane, whether dispelled by cough or removed by instruments inserted through the wound; it enables a more efficient application of local remedies to retard the congelation of the exudation into membranes or casts; and thus facilitates the discharge of the plastic material by cough. In short, it gives the patient a chance, offered by no other means, to live and fight through the development and decline of the disease.

On the other hand, in some unhappy examples tracheotomy has been only a prelude to the post-mortem examination; while a number of instances are on record in which death occurred during its performance, even under the hands of skilful and experienced operators.

The chief objections to tracheotomy, apart from its infrequent success,—which, nevertheless, is as proportionately great as that in many so-called capital operations considered fully justifiable,—are certain accidents incident to the operation itself, and the methods of treatment after it. To these, attention will be given in a subsequent portion of this paper.

Modern medical literature teems with statistics as to the results of tracheotomies for croup; some presented in units, some in tens, some in hundreds, and some in thousands. Hundreds of individual cases have been recorded, with more or less detail. Their study leads but more and more to the conclusion that in croup, as in many more purely surgical affections, the decision as to the propriety of the operation must be made with reference to the individual case in question, rather than with regard to the proportionate number of recoveries reported in the journals.

Though the operation had been suggested by Asclepiades, it was not until 1782 that the first successful tracheotomy for croup was performed by John Andree,[1] in London. The second was by Thomas Chevalier, of London, in 1814.[2] Bretonneau followed in France, and after two unsuccessful cases in 1818 and 1820 respectively, performed a successful tracheotomy in 1825. In 1829 Prof. Stolz per-

[1] Farre; Appendix to a paper on Cynanche laryngea, Med.-Chir. Trans., iii. 1812, p. 335. (Borsieri; tome iv. Angina trachealis, § ccccxxxvi.) Trousseau; Clin. Med., Sydenham Soc. Trans., vol. ii. p. 594.

[2] Account of a case of Croup in which the operation of bronchotomy was successful, Med.-Chir. Trans., vi. 1816, p. 151.

formed the first operation in Strasbourg.[1] Trousseau reported his first successful case in 1833;[2] and remained the most zealous advocate of the operation during his entire life.

Success prior to 1850 was comparatively infrequent. About that period a greater amount of care began to be taken in the performance of the operation, and in the details of the after-treatment; in consequence of which, the ratios of success soon became much larger.

A number of collections of statistics, culled from various duly acknowledged sources, and comprising several thousand cases, is herewith presented. Most of them deal with generalities only; but some of them are accompanied with references to recorded details which can be consulted with more or less satisfaction.

The writer will be glad if any of his readers, who have facilities for so doing, would perfect these statistics and publish them. A complete record from the two Parisian Hospitals for Children, if officially correct, would be of great value. The notes appended to some of these statistics, referring to other figures representing the same sources, show how little they can be depended upon for rigid investigation.

It is not an easy matter to estimate the comparative value of statistics. Isolated records of individual operators do not represent the full number of scattered recoveries, and still less the full number of scattered deaths; but, inasmuch as successes are more apt to be heralded than failures, the actual proportion of recoveries in the hands of those who are only occasionally called upon to perform the operation, is perhaps less than would appear from an exhibit of statistics of this class of records. The private statistics of operating surgeons who keep records of all their cases, and the statistics of hospitals, when officially correct, are the only ones of real value in this connection, taking cognizance of figures merely. Hospital cases in themselves, as a rule, offer less chance of recovery than cases in private practice, though the operation is frequently performed better, and the after-treatment is much more assiduous. The general character of the run of cases has a like influence on both classes of cases; but the hygienic condition of the patient, the period of the disease at which it comes under observation, and the character of the previous treatment, considerations of great importance with reference to results of tracheotomy, are much less favorable in hospital practice. Hence we find the percentage of mortality varying from 60 per cent. in some seasons, to 90 per cent. in others.

[1] Gaz. méd. de Strasbourg, Dec. 31, 1867, p. 295.

[2] Journal des Connaissances medico-chirurgicales, 1 Sept. 1833.

Barthez says,[1] "What gives great value to the results obtained in hospitals is, that the greatest number are brought to the hospitals after the failure of medical treatment; and many of them in such a condition that death is nearly or quite imminent. Sometimes our assistants have hardly time enough to prepare their instruments for operation: there is great emergency; and all those saved by the operation under such circumstances are simply snatched from certain death."

But how are we to estimate the percentage of recoveries in desperate cases without tracheotomy? how estimate the percentage that die for want of tracheotomy? how estimate the number of awkward tracheotomies? how estimate the number of deaths due directly to the operation itself, or to untoward circumstances that follow it? how estimate the number operated upon when half dead, or in articulo-mortis? how separate the causes of death after tracheotomy; whether incident to the disease, to previous exhaustive treatment, to the operation itself, to inefficient after-treatment of the wound or of the disease?

These are important questions in connection with a correct appreciation of the value of tracheotomy; but they cannot be satisfactorily answered.

Statistics from French Sources.

In a discussion which took place in the Parisian Academy of Medicine in 1839,[2] the following results were presented:—

Operators.	No. of Tracheotomies.	Recoveries.
Amussat	6	0
Baudelocque	15	0
Blandin	5	0
Bretonneau[3]	18	4
Gerdy	6	4
Roux	4	0
Trousseau[4]	80	20
Velpeau[4]	6	0
	140	28

A still less favorable exhibit was alluded to by Malgaigne in another famous discussion before the Academy in 1858:—[5]

[1] Gaz. méd. Paris, 1868, p. 449.

[2] Bull. de l'Acad. de méd. for that year; and again for 1858-9.

[3] Later statistics concerning Bretonneau give 20 operations and 6 recoveries. Am. Journ. Med. Sci., April, 1849, p. 335, Meigs. Bouchut; Slade on Diphtheria, 1861, p. 72.

[4] Meigs, Am. Journ. Med. Sci., April, 1849, p. 331, quotes Trousseau as having at that time (1849) saved 27 out of 119; and p. 335, Velpeau, 2 out of 10.

[5] Bull. de l'Acad. de méd., xxiv. 1858-9, p. 168.

Operators.	No. of Tracheotomies.	Recoveries.
Gosselin	23	0
Michon	20	2
Laugier	8	1
Nélaton { before 1848, 23 / after " 13 } .	36 { before 1848, 0 / after " 3 }	3
Monod, Jr. . . . (about)	40	0
Theirry . . (in children)	37	3
" . . .(in adults)	3	0
Malgaigne	8 (or 10)	1
	175	10

During this latter discussion, Trousseau presented the following additional statistics :[1]—

Operators.	No. of Tracheotomies.	Recoveries.
Bardinet (and confrères at Limoges)	57	17
Saussier (Troyes)	6	3
Beylard (Paris)	13	4
Moynier[2] (Paris)	17	8
Archambault[3] (Paris) . . .	21	8
Perrochaud (Boulogne) . . .	3	2
Delarue (Paris)	3	1
Lalois (Belleville)	6	3
Viard (Montbard)	2	1
Petel[4] (Cateau)	9	5
Baudin (Nantua)	4	3
Dubarry (Condom)	5	2

And Trousseau adds as a separate list showing results better than those achieved at an earlier date.[5]

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[1] Bull. de l'Acad. méd., xxiv. p. 231. See also Gaz. hebd., Dec. 3, 1858, p. 844.

[2] Dr. Eugene Moynier, in a monograph entitled "Compte rendu des faits de diphtherie observés dans le service de M. le Professeur Trousseau, pendant le premier semestre de l'anné 1859," reprinted from the Gaz. des hôp., states that he had performed the operation 25 times with 11 recoveries; 20 times with 8 recoveries in hospital, and 5 times with 3 recoveries in private practice. See Union méd., Jan. 1866.

[3] Later statistics furnished by Archambault in discussions at the Société médicale des hôpitaux de Paris, in 1867 (Bulletins et Mémoires de la Société, etc., t. 4, 2me sér. 1867, p. 185), sum up two unsuccessful cases in adults, and 22 recoveries out of 65 tracheotomies in children; all in private practice; 55 of them operated upon in the period of asphyxia; most of them at the last extremity; some of them sufficiently insensible to enable him to operate without assistance. The details are exhibited at p. 201. See also Gaz. des hôp., 1867; Ed. Med. Journ., Nov. 1867; Am. Journ. Med. Sci., April, 1868.

[4] Concerning 6 of these cases with 3 recoveries, consult Journ. des Conn. med.-chir., Oct. 1841; Am. Journ. Med. Sci., April, 1842, p. 472.

[5] Bull. de l'Acad. méd., xxiv. p. 233.

Operators.	No. of Tracheotomies.	Recoveries.
Richet	9	5
Follin	7	2
Broca	12	6
Richard	5	2
Demarquay	6	2
	185	74

Hôpital des Enfants Malades.

Previous to 1849 the operation had been performed 49 times in this hospital, with only one recovery.[1]

The success immediately after 1849 was in remarkable contrast, as will be seen by the following exhibit:—[2]

Years.	No. of Tracheotomies.	No. of Recoveries.
1850	20	6
1851	31	12
1852	59	11
1853	61	7
1854	44	11
1855	48	10
1856[3]	55	14
1857[4]	71	15
1858	90	30
1859	164	40
1860	130	23
1861 (10 months)	82	25
1862	136	29
	991	233

[1] Trousseau, Union médicale, Aout, 1851. See Nos. 2, 5, 19, 21, 23.

[2] The statistics for 1850–1857 are from H. Chaillou, Am. Journ. Med. Sci., July, 1858, p. 251; for 1858 from Bouvier, Bull Acad. méd., xxiv. 1858–9, p. 191; for 1859–1861 from Haughton, Trans. Indiana State Med. Soc. 1867, p. 125; and for 1862 from Barthez, Gaz. méd. Paris, Aug. 1, 1868, p. 449.

[3] For details concerning this year, see thesis of André, Du traitement des cas de croup observés à l'hôpital des Enfans en 1856, Paris, 1857, which gives 15 recoveries out of 54 operations. His observations were made in the male wards. See, also, Bull. de Thérap., May 30, 1857, p. 471, with table: Brit. and For. Med.-Chir. Rev., July, 1857; Amer. Journ. Med. Sci., Oct. 1857.

[4] Millard, in a thesis, "De la trachéotomie dans le cas de croup," Paris, 1858, based on observations in the female wards during his service, made between January, 1857, and July, 1858, gives a result during that period of 21 recoveries among girls out of 62 operations, and 8 recoveries among boys out of the same number; the sum total being 124 operations and 29 recoveries. Of 20 operated upon under 2 years of age, none recovered; of 36 between 2 and 3 years, only 5 recovered; the remaining 24 recoveries being in children between 3 and 9 years of age. In a letter in answer to some strictures of Malgaigne (see

MM. Fischer and Brichetau[1] give the following table as the results in this hospital for the 12 years, 1851–1863:—

	No. of Operations.	No. of Recoveries.
On boys	539	131
On girls	474	133
	1013	264

Hôpital Sainte-Eugénie.

Barthez, in a letter[2] to Rilliet on the comparative results of the treatment of croup by tracheotomy and by medication, during the years 1854–1858, states that the first year after the Hôpital Sainte-Eugénie was opened, 13 cases were operated on with but one success, and that the last of the series. Meanwhile 4 cases recovered that were not operated upon: 13 operations, 1 recovery. The next year, of 18 cases 4 recovered; in two of which the operation had been performed: operations 16, recoveries 4.[3] In 1856 there were 18 cases and 4 recoveries, of which 3 had been operated on. In 1857 there were 33 cases with 9 recoveries, 7 of which had not been operated on; and of these, two had been sent back from the operating table to await further result from medical treatment; while of 22 operated on, only 2 recovered: operations 22, recoveries 2. In 1858 there were 124 operations with 18 recoveries, and 36 recoveries out of 62 cases not operated on: operations 124, recoveries 18.

The following statistics are from Bouchut,[4] and are not in accord with this letter of Barthez as far as they go:—

Bull. de l'Acad. méd. 1858–9, and Gaz. hebd., Nov. 26, 1858, p. 826) he states that in but one of these cases was there no evidence of false membrane.

Messrs. H. Roger and G. Sée, physicians to the same hospital, reported (see Gaz. hebd., Nov. 12, 1858, p. 789; Nov. 26, p. 817; and Bull. de l'Acad. méd., xxiv. pp. 115 and 125) some observations based upon nine years' practice in the hospital, from June 1, 1850, to Oct. 15, 1858. The whole number of croup cases was 562; the number of operations 466 (incorrectly stated in many journals as 446); recoveries after operations 126; recoveries without operation 49. They mention that 25 cases were saved out of 39 operated on before complete asphyxia had occurred. The proportion of recoveries in children between 6 and 12 years of age was 44 in 100. In several articles I have read, these statistics of operations and recoveries are incorrectly attributed to the personal experience of Trousseau.

[1] Traitement du Croup, ou Angine laryngée diptheritique. Second edition. Paris, 1863. Gürlt's Jahresbericht, p. 563, in vol. viii. Arch. klin. Chir.

[2] Gaz. hebd. Dec. 2, 1859; Brit. and For. Med.-Chir. Rev., Apl. 1860; Am. Journ. Med. Sci., July, 1860.

[3] Bouvier, Bull. Acad. méd., xxiv. p. 192.

[4] Traité Pratique des Maladies des Enfants, etc. Paris, 1862, p. 277.

Years.	No. of Tracheotomies.	No. of Recoveries.
1854 (March 15 to December 31)	6	0
1855	9	3
1856	13	5
1857	25	6
1858	119	21
1859	123	20
1860	55	7
1861 (January 1 to April 30)	24	2
	374	64

Then we have the following figures[1] from Bourdillat,[2] the house surgeon of Bergeron:—

Years.	No. of Tracheotomies.	No. of Recoveries.
1860	55	8
1861	76	13
1862[3]	111	22
1863	112	34
1864	121	15
1865	147	46
1866	129	45
1867 (first 6 months)	62	25
1867 (second 6 months[4])	40	8
	853	216

Barthez[5] gives the following figures:—

	Operations.	Recoveries.
For 1861–1867	785	222
And for 1866 and 1867	223	79

	Operations.	Recoveries.
Taking Bouchut's list from 1854 to 1859	295	55
Bourdillat's list from 1860 to 1867	853	216
Sanné's[6] list for 1868	83	18
And Vaslin's list for 1869[7]	30	10
We have a total for 15 years of	1261	299

As the results of Sainte-Eugénie.

[1] Statisque pour servir à l'histoire de la trachéotomie. Gaz. des hôp. Paris, 1867, No. 89.

[2] Bourdillat had operated himself 16 times with 10 successes. These cases are described in the Bull. et Mém. de la Soc. méd. des hôp., Paris, 1867, p. 221.

[3] Barthez, Gaz. méd., Paris, 1868, p. 449, gives the following results: operations 113, recoveries 24.

[4] Bull. et Mém. Soc. méd. hôp. 1868, p. 38.

[5] Gaz. méd., Paris, 1868, p. 449.

[6] Étude sur le croup après la trachéotomie. Paris, 1869, p. 8.

[7] Gaz. des hôp., Mch. 5, 1870. Bergeron's wards.

But it will be seen elsewhere, as in these exhibits, that the figures drawn by different observers from the same sources are by no means identical; and therefore it is impossible to know what the correct figures are. It is for this reason that they have been displayed, with references for detailed information, without any attempt to add up the entire number of cases tabulated in this paper, which, however, without any doubling, amount to upwards of 5000.

Sanné[1] gives quite a different list for some of these years, as follows:—

Year.	No of Operations.	No. of Recoveries.
1855	9	2
1856	14	3
1858	73	11
1859	76	20
1860	34	7
1861	37	7
1862	62	19
1863	54	18
1865	29[2]	27
1866	64	29
1867	39	10
1868[3]	82	17

Fischer and Brichetau[4] give the following schedule as the experience at the hospital for the years 1854–1861:—

	No. of Operations.	No. of Recoveries.
On boys	225	38
" girls	171	29
	396	67

To these may be added further statistics from French sources:—

Operator.	No. of Tracheotomies.	No. of Recoveries.
Trousseau[5] (1851–4, private practice)	24	14
Isnard[6]	4	2
Baizeau[7] (Paris)	12	4
Bœckel[8] (Strasbourg)	33	12
Schœllhammer[9] (Haut Rhin)	7	6

[1] Étude sur le croup après la trachéotomie, Paris, 1869, p. 49.

[2] An uncorrected typographical error evidently.

[3] In his introduction, p. 8, the figures for the year are 83 operations, and 18 recoveries, being the cases on the individual observation of which his volume is based.

[4] Op. cit.

[5] Arch. gén. de méd., March, 1858, p. 259; of these, in 1854, 9 operations, 7 recoveries.

[6] Union méd. 1859, 47.

[7] Gaz. des hôp., 1867, p. 397.

[8] De la trachéotomie dans le croup. Strasbourg, 1867. Reviewed in Gaz. méd. de Strasbourg, Dec. 31, 1867, p. 295; with details of these 33 personal cases.

[9] Bœckel, op. cit.

Operator.	No. of Tracheotomies.	No. of Recoveries.
(Other operators)[1]	43	16
Calvet[2] (Castres)	23	13
Henriette[3] (Brussels) . . .	8	4
	154	71

Dr. P. M. Braidwood, in an article on "Tracheotomy in the Treatment of Croup and Diphtheria,"[4] sums up, but without giving any references, 922 cases with 345 recoveries, at the hands of various operators whose names are given. They are all included in the exhibits in this paper, with the exception of a result accredited to Barthez (Paris) of 110 recoveries in 142 cases. It is likely that these cases, or most of them, are included in the statistics presented from the Sainte-Eugènie Hospital; though the unusually large proportionate number of recoveries would rather indicate operations in private practice. In an extensive course of research, I have not elsewhere come across this series of Barthez, and am, therefore, unable to verify it; though as far as my memory serves, all the remaining statistics have been verified by my own researches, which would indicate that these figures are correct also; but being so disproportionate to anything else I have seen, it has not, for the reason intimated, been included in any of the lists.

Guersant[5] stated in 1864, that he had performed in all 156 operations with 28 recoveries; but that previous to 1845, up to which time he had used a single tube and had not employed a cravat, he had saved but 2 cases out of 32 operations. His results would be as follows:—

	No. of Operations.	No. of Recoveries.
Between 1834 and 1845 . .	32	2
After 1845	124	26
	156	28

He also stated that he and his assistants had performed, in hospital between the years 1850 and 1861, 781 operations with 191 recoveries.

[1] Bœckel, op. cit.

[2] Reflexions suivies de quelques observations de trachéotomie dans la dernière période du croup. La Revue médicale de Toulouse. 8 successes out of 15 operations performed between May, 1864, and April, 1866. See remarks by Armand Rey; Le mouvement médical, March 29, 1868, p. 151. Also a report (verbal) by Giraldes on the whole number, Gaz. hebd. 1868, No. 43, p. 685.

[3] Presse méd. Belge, No. 34; Med. Times and Gaz., Sept. 18, 1860, p. 247.

[4] Liverpool Med. and Surg. Rep., iii., Oct. 1869, p. 9–16.

[5] Gaz. des hôp., 1864, p. 99. See also Med. and Surg. Rep., Philada., 1864, p. 9, from Brit. Med. Journ.

STATISTICS FROM SPANISH SOURCES.

Operator.	No. of Tracheotomies.	No. of Recoveries.
da Silva[1]	14	4
Barbosa[1]	15	6
Carvalho[1]	3	1
(Other operators)[1] . . .	6	1
	38	12

Only one child under 4 years of age was saved, and none between the ages of 7 and 17 years.

STATISTICS FROM GERMANIC SOURCES.

Operators.	No. of Tracheotomies.	No. of Recoveries.
Uhde[2] and others (Braunschweig)	81	21
Kühn[3] and his collected statistics	277	125
Fock[4] and others (Magdeburg) 1856–1861	43	18
Simon[5] (Rostock) . .	22 { 1 in an adult, fatal }	6
Burow[6] (Königsberg) . .	51	7

[1] Barbosa; Memoria sobre a Tracheiotomia no Garrotilho; Lisbon, 1863. Brit. and For. Med.-Chir. Rev., 1864, p. 63; Union méd., 1864, p. 362; Gürlt's Jahresbericht, p. 564, in vol. viii. Arch. klin. Chir.

[2] Zusammenstellung der in Herzogthum Braunschweig vom Nov. 23, 1720, bis zum Apl. 1869, ausgeführten Luftrohrenschnitte. Arch. für klin. Chir., xi. 1869, p. 743. Death occurred during the operation in 5 cases; in a few minutes, in 7 cases; within twenty-four hours, in 18 cases; between the second and third day, in 18 cases; and between the fifth and eighth day, in 4 cases.

[3] In Günther's Lehre von den blutigen Operationen; Leipzig and Heidelberg, 1864, vol v. These are collected from individual reports, and include French and other records; and doubtless a large number of them represent cases included in other tables in this exhibit. The proportionate number of recoveries is much larger than a promiscuous collection of individual and other records would show in my own hands.

[4] Deutsche Klinik, 1861, p. 134. Of these cases 16 operations with 8 recoveries were personal. Gürlt's Jahresbericht, p. 312, in Arch. für klin. Med. iii. See also for 24 operations and 10 recoveries, Deutsche Klinik, 1859, Nos. 23, 24, 25; Canstatt's Jahresbericht, iv. p. 391; Kühn, op. cit.; Brit. and For. Med.-Chir. Rev., July, 1860; Am. Journ. Med. Sci., Oct. 1860. It is likely that these statistics include among others those of Sendler, of Magdeburg, 5 operations and 2 recoveries, detailed in the Präger Vierteljahrschrift, 1859, iv. p. 57.

[5] Schmidt's Jahrbücher, 1868, Bd. 140, p. 238.

[6] Deutsche Klinik, 1862, p. 382; Gürlt, op. cit., p. 226, Arch. klin. Chir., v. 1864.

Operators.	No. of Tracheotomies.	No. of Recoveries.
Roser[1] (Marburg) . .	42	19
Burow, Jr.,[2] 1863 (Königsberg) 7 infants and 1 adult .	8	0
Schmidt[3] (Leipzig) . .	15	2
Symwrhid[4] (St. Petersburg?)	4	2
Ebert,[5] 1859–1865 (Berlin) .	13	6
Widerhofer,[6] reported by, (Vienna)	19	2
Hauner[7] (Munich) . .	17	2
Rinecker[8] (Wurzburg) .	?	0
At the Kinderspitale[9] (Prague)	24	6
Busch[10] (Berlin) . . .	72	10
Molendzinski[11] (Lemberg) .	2 (1 adult)	0
Oelschlœger[12] (Danzig, 1856–1869) . . .	12	1
Billroth[13] (Zurich) . .	12	1
Reiffer[14] (Frauenfeld) . .	18	8
Güterbock,[15] report (Berlin) 1861–1867	100	34
Heuter[16] (Rostock) . .	29	7
Steiner,[17] 4 years (Prague) .	52 { boys 33, girls 19,	18 { boys 11, girls 7.
[Jaffé,[18] report? (Germany) .	294	65]
Titanus[19] (Amsterdam) .	80	28
Müller,[20] 1862–1869 (Cologne)	45	15

[1] Sydenham Soc. Year Book, 1863, p. 278; Gürlt, op. cit., 1861–2, p. 306, Arch. klin. Chir., iii.

[2] Deutsche Klinik, 1863, p. 58; Gürlt, op. cit. [3] Kühn, op. cit.

[4] Gürlt's Jahresbericht, p. 562, in Arch. klin. Chir., viii.

[5] Berlin klin. Woch., 1865, pp. 474–482; Gürlt, op. cit., p. 565. Results in the Kinderklinik der Charité, Berlin, from June, 1859, to March, 1865. See also Jaffé, Schmidt's Jahrb., 1868, Bd. 140, p. 210.

[6] Gürlt, op. cit. Results in St. Annen-Kinderspitale, Wien, to Jan. 1864.

[7] Gürlt, op. cit. München Kinderspitale.

[8] Ibid. Julius-spitales. [9] Ibid.

[10] Ibid. Universitäts-Klinikum, 1869. [11] Ibid.

[12] Arch. klin. Chir., xi. 1869, p. 841

[13] Arch. klin. Chir., 1869, x. p. 191. [14] Billroth, loc. cit., p. 193.

[15] Arch. d Heilk., 1867, viii. No. 6, p. 516; Jaffé, loc. cit., 149, p. 222.

[16] Zur Lehre von der Tracheotomie, resp. cricotomie, und ihre Erfolge bei Diphtheritis; Berlin. klin. Woch., 1869, No. 30 et seq.

[17] Jahrb. d Kinderheilkunde, 1868, No. 1; Präger Vierteljahr., 1868, iii.; Am. Journ. Med. Sci., Oct. 1868. The details have been translated into English by Dr. John C. Jay, Am. Journ. Obstet., 1871, p. 583.

[18] Braidwood, Liverpool Med. and Surg. Rep., iii., Oct. 1869.

[19] Ibid.

[20] Beitrag zur Statistik der Tracheotomie bei Croup. Arch. klin. Chir., 1871, p. 432. The general results are detailed with great care.

Operators.	No. of Tracheotomies.	No. of Recoveries.
Wilms,[1] 1861–1872 (Berlin)	335	103
Fröbelius[2] (St. Petersburg)	2	0
Balassa[3] (Pesth)	2	2
Pletzer[4] (Bremen)	3	1
Bartels[5] (Kiel)	61	17
von Köpl[6]	17	11
Mörath[7]	1	1
Stelzner[8] (Dresden)	12	4

Statistics from British Sources.

	No. of Tracheotomies.	No. of Recoveries.
Spence[9] (Edinburg)	87	28
Buchanan[10] (Glasgow)	39	13
Cruickshank[11]	11	8
H. W. Fuller[12] (report of)	7	3

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[1] Bartels, Jahrb. f. Kinderheil.; The Medical Record, N. Y., Sept. 1, 1873, p. 428.

[2] Petersb. med. Ztschr., xii. 4, 1867, p. 356; Jaffé, Schmidt's Jahrb., 1868, Bd. 140, p. 215.

[3] Wien. med. Woch., xiv. 1864, 18 and 19; Jaffé, Schmidt's Jahrb., 1871, Bd. 149, p. 217.

[4] Hannov. Ztschr. 5, 1865; Jaffé, Schmidt's Jahrb. 149, p. 218.

[5] Jaffé, ibid., p. 219, from Deutsches Arch. klin. Med., 1866, ii. 4 and 5.

[6] Sitzungsberichten des Vereins der Aerzte in Steiermark, Graz., 1870; Jaffé, loc. cit., 149, p. 332.

[7] Ibid.

[8] Jaffé, Schmidt's Jahresbericht, 1870, Bd. 149, p. 335.

[9] Braidwood's table. Liverpool Med. and Surg. Reports, 1869, iii. p. 15. See also James Spence, Cases of Tracheotomy in Croup, with clinical remarks. Edin. Med. Journ., Feb. 1860, p. 693. Tracheotomy in Diphtheritic Croup. Ibid., March, 1864, p. 777.

[10] Brit. Med. Journ., March 4, 1871, p. 217. Also St. Andrew's Medical Graduates' Association Transactions, 1867, p. 161. During the seven years in which 31 of these cases with 11 recoveries had occurred, Dr. Buchanan had been called to 40 cases as an operating surgeon; all of those not operated upon died. Dr. Buchanan, Brit. Med. Journ., March 25, 1871, p. 310, tabulates his 39 cases, of which 19 were under 4 years of age, two of whom recovered. This is an answer to a note from Vincent Jackson, Brit. Med. Journ., March 18, 1871, p. 278, condemning tracheotomy in patients under 4 years of age. See also note from C. E. Saunders, Brit. Med. Journ., April 1, 1871, p. 337.

[11] Reynold's System of Medicine, vol. i. p. 101. Aitken's Practice, Philada., 1868, 1, p. 533.

[12] Med.-Chir. Trans., 1857, xl. p. 39. Five (with postscript seven) cases of Tracheotomy in Croup, with remarks. See also Am. Journ. Med. Sci., April 1857, p. 525, from Med. Times and Gaz., Feb. 7, 1857.

	No. of Tracheotomies.	No. of Recoveries.
Conway Evans[1]	5	1
Henry Smith[2] (London) . .	3	0
Ransom[3] (Nottingham) . .	3	0

London Hospitals.[4]

Hospital.	No. of Operations.	No. of Recoveries.
St. George's Hospital[5] . .	6	3
Dreadnought Hospital-Ship .	1	0
Metropolitan Free Hospital .	1	0
Hospital for Sick Children[6] .	3	0
King's College Hospital . .	1	0
The Middlesex Hospital[7] . .	1	0
St. Mary's Hospital . . .	1	0
Addenbrooke's Hospital (Cambridge)	1	1
	170	57

Statistics from American Sources.

Operators.	No. of Tracheotomies.	No. of Recoveries.
Physick[8] (Philada.) .	2	0
Pancoast[9] " . .	9	4
Page[10] " . .	1	0
Smith[11] " . .	1	0
Goddard[12] " . .	2	0
Hewson[13] " . .	1	0

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[1] Edin. Med. Journ., Nov. 1859, p. 397; Jan. 1860, p. 618; May, 1860, p. 1008. On Tracheotomy in Croup. One death during operation. Am. Journ. Med. Sci., Oct. 1859, p. 548.

[2] Med. Times and Gaz., March 5, 1853, p. 244 (Ibid. Jan. 26, 1856); Am. Journ. Med. Sci., April, 1856, p. 495.

[3] Brit. Med. Journ., Sept. 17, 1864.

[4] For details see Med. Times and Gaz., Oct. 15, 1859, p. 379. No. of operations incorrectly summed up as 14.

[5] One of the unsuccessful cases was 16 years of age.

[6] Mr. Holmes (Surgical Treatment of Diseases of Children, Philada., 1869, p. 302) states "that at the children's hospital, out of fifty recorded cases of operations for diphtheria and croup, performed by several different operators during the last twelve years, five only have recovered. In 31 cases the causes of death have been noted; and in very few of these cases was the cause of death connected in any way with the operation.

[7] Brit. Med. Journ., Feb. 17, 1866. 6 cases, 1 in an adult; all fatal.

[8] Meigs and Pepper.

[9] H. H. Smith, Operative Surgery, Philada., 1863, p. 271. In 1848, Pancoast operated in three cases for Dr. Meigs, two of which were successful, one at 19 months. Am. Journ. Med. Sci., April, 1849.

[10] Ibid.

[11] 1852, Ibid. Philada. Med. Exam., viii., N. S., p. 222.

[12] Meigs and Pepper.

[13] Ibid.

Operators.	No. of Tracheotomies.	No. of Recoveries
Levis[1] (Philada.) . .	12	1
Packard[2] " . .	1	0
Hodge[3] " . .	4	3
Drysdale[4] " . .	4	1
Bolling[5] " an adult .	1	0
Grove[6] " . .	1	1
Cohen " . .	1	0
Bache[7] " . .	1	0
Keen[8] " . .	1	0
Allis[9] " . .	1	0
(Other operators)[10] .	8	0
Thompson[11] . . .	1	0
E. Atlee[12] (Lancaster, Pa.)	1	0
Townsend[13] (Boston) .	1	0
Bigelow[14] " . .	1	0
Gay[15] " . .	13	7
Cabot[16] " . .	2	2
Cheever[17] " . .	9	6
Buck[18] (New York) .	2	2
Ayers[19] " . .	1	1
Van Buren[20] " . .	1	0
Minor[21] " . .	6	2
C. K. Briddon[22] (New York) .	5 (1 in an adult)	0
Jacobi[23] (New York) .	67	13

[1] Verbal communication. See also Meigs and Pepper, On Diseases of Children.

[2] Am. Journ. Med. Sci., Jan. 1870, p. 95.

[3] Verbal communication. See also Meigs and Pepper; and Cleeman; Am. Journ. Med. Sci., April, 1870, p. 567.

[4] Verbal communication. [5] Ibid. [6] Ibid.

[7] Am. Journ. Med. Sci., July, 1869, p. 112.

[8] Philada. Med. Times, April 15, 1871, p. 263.

[9] Ibid, June 1, 1871, p. 322. [10] Verbal communications.

[11] Smith, Operative Surgery; Philada. 1863, p. 271; 1816, N. E. Journ. Med. and Surg., vol. v. p. 318.

[12] 1831, Ibid. West. Journ. Med. and Phys. Sci., iv. p. 23.

[13] 1849, Ibid. Am. Journ. Med. Sci., xvii., N. S., p. 28.

[14] 1853, Ibid. Am. Journ. Med. Sci., xxvi., p. 80.

[15] Boston Med. and Surg. Rep., Jan. 27, 1858.

[16] Ibid., Feb. 1861; Am. Journ. Med. Sci., April, 1861, p. 608.

[17] Boston City Hospital Reports, 1870.

[18] 1851, H. H. Smith, op. cit. N. Y. Journ. Med., N. S., vii. p. 269.

[19] 1852, Ibid. N. Y. Journ. Med., N. S., ix. p. 69. [20] Ibid.

[21] N. Y. Journ. Med., 1860, p. 242.

[22] Am. Med. Times, 1863, p. 227. [23] Am. Journ. Obstet., May, 1868.

Operators.	No. of Tracheotomies.	No. of Recoveries.
Voss[1] (New York) .	43 { 6 before 1858, 36 after "	10 { 5 before 1858, 5 after "
Krackowitzer[2] (New York) . .	55	16
von Roth[3] (New York) .	48	11
Johnson, C. P.[4] (Richmond, Va.) . .	1	0
Johnson[5] . . .	1	0
Burgess[6] . . .	2	1
McIlvaine[7] (Charlotte, N. C.) . . .	1	0
Pitney[8] (Moorestown, N. J.) . . .	1	1
Haughton[9] (Richmond, Indiana) . . .	5	1
Prentiss[10] (Washington)	1	0
Lincoln[11] . . .	1	0
Fenner[12] (Memphis, Tenn.) . . .	5	1
	325	84

THE AGE OF THE PATIENT, taking an extensive range of statistics, has an important influence on the success of tracheotomy for croup. Very few children under two years are saved; very few over eight or nine; and adults seldom or never. In an important discussion upon tracheotomy in croup which occurred at the Parisian Société des hôpitaux in 1867, Isambert stated[13] that during his two years of service (1853–1855) in the Hôpital des Enfants Malades, under Guersant and Blache, it was almost a rule that no case under two years of age, or at least under twenty months, should be operated upon, because of the insuccess that attended them. Indeed, it was erroneously stated by one member that no case under two years of age had ever recovered after the operation in the public hospitals of Paris. Several cases of recovery at an early age were

[1] Jacobi, loc. cit. [2] Ibid. [3] Ibid.

[4] 1851, H. H. Smith, op. cit. Stethoscope, vol. i. p. 670. Am. Journ. Med. Sci., Jan. 1852, p. 286. [5] Ibid.

[6] 1824, Ibid. Am. Med. Recorder, vii. p. iii.

[7] 1851, Ibid. Am. Journ. Med. Sci., xxi., N. S., p. 387.

[8] 1852, Ibid. N. J. Med. Rep., v. p. 332.

[9] Trans. Indiana State Med. Soc., 1867, p. 126.

[10] Am. Journ. Med. Sci., April, 1868, p. 412. [11] Prentiss, loc. cit.

[12] N. A. Med.-Chir. Rev., 1860, p. 854. I have a personal knowledge of the successful case, and believe it to have been croup, though Dr. Fenner has doubts on the subject.

[13] Bull. et Mém. de la Soc. méd des hôp. de Paris, t. iv 2me sér., année 1867.

mentioned during the course of that discussion which occupied several sessions. These are included in a table of successes at an early age which has been compiled in this connection.

Vincent Jackson,[1] in a note published in 1871, condemned tracheotomy in children under four years of age. This note was answered by Dr. Buchanan,[2] in which he tabulates his 39 cases of tracheotomy for croup, showing that of 19 operations performed by him in children under four years of age, recovery took place in two instances.

Roger and Sée, in their reports of 1851–8 (126 recoveries in 466 operations), state[3] that 44 out of 100 were saved between six and twelve years of age; and Roger asserted, in the discussion above referred to, that patients did not recover well after nine years of age, and that there was not a case on record of recovery in the adult. In the course of these pages there are a number of references to operations in the adult; not one of them resulted in recovery. Trousseau attributed the want of success in the adult to the fact that asphyxia, owing to the large size of the larynx, is retarded until the exudation has invaded the bronchi.

Trousseau, in his Clinical Medicine, endorses the following quotation from Dr. Michel Peter:—[4]

"Children below two, and up to two and a half years of age, seem to sink under the influence of traumatic fever; and it is generally during the twenty-four or thirty-six hours which immediately follow the operation, that death occurs. Scarcely have two hours elapsed after the operation, when the number of pulsations and respirations increase in a remarkable manner, and the temperature of the skin rises in the same ratio. Then, little by little, the face becomes red, and there is burning thirst, while the heat of the body is dry and intolerable. The child sinks into a slumber, which is occasionally disturbed by some convulsive movements, and then he dies."

In the table of Prof. Wilms, of Berlin (103 recoveries in 335 cases), six cases were operated on at less than two years of age, and six between the ages of eleven and fourteen years inclusive. Not one of these recovered. Thierry has reported three unsuccessful cases in the adult, and Archambault two. At St. George's Hospital, London, a fatal case occurred at sixteen years of age, in a girl operated on just before death.[5] Prof Billroth has reported[6] an

[1] Brit. Med. Journal, March 18, 1871, p. 278.

[2] Ibid., March 25, 1871, p. 310. [3] Gaz. hebd., Nov. 12, 1858, p. 789.

[4] Relation d'une Epidémie de diphtherie observée à l'hôpital des Enfants en 1858. Mémoire couronnée par la Faculté en 1859.

[5] Med Times and Gaz., Oct. 15, 1859, p. 379.

[6] Arch. klin. Chir., 1869, p. 191.

operation in a female over twenty years of age, who died on the fourth day from mediastinitis, pleuritis, and septicæmia.

From an examination of the records of a period of ten years, comprising some 1300 croups, Bourdillat[1] found that the average recovery after tracheotomy had been as follows:—

Under 2 years	. . . .	3	out of the 100.
At 2 "	. . . .	12	" "
From 2½ to 3 years	. . .	17	" "
" 3½ to 4 "	. . .	30	" "
" 4½ to 5 "	. . .	35	" "
" 5½ to 6 "	. . .	38	" "
Above 6 years	. . . .	41	" "

Sex did not appear to have any influence on mortality.[2] This exhibit, says Bourdillat, comprises the law laid down by Millard, that, "all things being equal, the chances of recovery are in direct ratio with the age of the patient." Deaths had been more frequent proportionately during the months of November, December, and January, doubtless as the effect of cold weather in inducing pulmonary complications.

Jacobi, of New York, in his article on this subject,[3] gives the following statement of the ages of the recoveries in his cases (13 out of 67):—

1 at 2½–3 years,	out of 5	operations	. . . .	20	per cent.
3 at 3 –4 "	16	"	. . . .	19	"
7 at 4 –5 "	23	"	. . . .	30	"
2 at 5 –6 "	7	"	. . . .	28⅔	"

Bartels[4] gives the following details of the cases occurring in Berlin (1861–1872) in the department of Prof. Wilms:—

Age.	No. of Tracheotomies.	No. of Recoveries.
Up to 2 years . .	6	0
Between 2 and 3 years	56	15
" 3 " 4 "	69	22
" 4 " 5 "	74	18
" 5 " 6 "	57	20
" 6 " 7 "	33	15
" 7 " 8 "	21	5
" 8 " 14 "	19	8
	335	103

[1] Bull. et Mém. Soc. méd. hôp., Paris, 1867, p. 39.

[2] The theses of Millard, and of Richet and Brichetau, and the report of Steiner, however, exhibit a remarkable preponderance of recoveries in the cases of female infants.

[3] Am. Journ. Obstet., May, 1868.

[4] Loc. cit.

Of six of these cases under two years, and of six between eleven and fourteen years of age inclusive, not one recovered. Inferior tracheotomy was performed under the influence of choloroform, and all bleeding vessels secured before the trachea was incised.

Guersant reported in 1847[1] a case of recovery at fourteen years of age.

Table of Operations on Adults.

Operator.	No.	Result.	Operator.	No.	Result.
Thierry .	3	D	Molendzinski	1	D
Archambault	2	D	Hulke[2] . .	1	D
Burow, Jr. .	1	D	Bolling . .	1	D
Simon . .	1	D	Briddon . .	1	D
Billroth . .	1	D		—	
				12, all fatal.	

Table of Successes at an Early Age.

Age at Operation.	Operator.
6 weeks	Scoutetten[3] (Strasbourg), 1840.
	Mr. Annandale has reported[4] a case operated upon at three months, which lived seven weeks.
7 months	Bell[5] (Edinburgh), 1861.
7 "	Lawson Tait[6] (Birmingham).
10 "	Baizeau[7] (Algiers).
10 "	Dujardin.[8]
10 "	Bourdillat[9] (Paris).
10 " (under 11 months)	J. Cooper Forster.[10]
13 "	Trousseau[11] (Paris), 1834.
13 "	Barthez[12] (Paris).

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[1] Gaz. des hôp. Feb. 23, 1847; Am. Journ. Med. Sci, Oct. 1847, p. 491. This was Guersant's fifth success out of forty-one operations.

[2] At Middlesex Hospital; Brit. Med. Journ. Feb. 17, 1866.

[3] For details see Am. Journ. Med. Sci. April, 1844, p. 466; from Med. Times, Jan. 20, 1844. Also Gaz. méd. 1845, p. 707; Gaz. hebd. 1862, Nov. 14, p. 723; Bull. et Mém. Soc. méd. hôp., Paris, 1867. This was an operation on his own child, the emergency being so great that the father could not wait for the friend who was to have performed it. Doubts have been expressed as to whether it was real croup.

[4] Ed. Med. Journ. 1862, p. 1121.

[5] Syme, Ed. Med. Journ. 1861, p. 956.

[6] Brit. Med. Journ. April 15, 1871, p. 391.

[7] Gaz. des hôp. 1867, p. 397.

[8] Union méd. 1872, No. 18. Canula worn eight months. A small fistule still remained at the end of four years.

[9] Gaz. des hôp. 1872, No. 64. Recovery slow; membranes expelled several times; canula retained fifteen days.

[10] Brit. Med. Journ., March 27, 1871, p. 309.

[11] Journ. des Conn. méd.-chir., Sept. 1834. Clinical Medicine, London Trans., ii. p. 614.

[12] Gaz. hebd. 1862, Dec. 19, p. 806.

Age at Operation.	Operator.
13 months	Archambault[1] (Paris)
15 "	Baizeau[2] (Algiers).
15 "	a colleague of Baizeau.[3]
16 "	Isambert[4] (Paris), 1867.

Potain reported a case at sixteen months which lived four weeks, and died from results of broncho-pneumonia, and tracheal ulceration from prolonged sojourn of canula. Bull. et Mém. Soc. méd. hôp. 1867.

17 months	Vigla.[5]
18 "	Moutard-Martin.[6]
18 "	Potain.[7]
19 "	Pancoast[8] (Philadelphia), 1848.
21 "	Sendler[9] (Magdeburg).
22 "	Labord,[10] 1862.
22 "	Isambert[11] (Paris), 1868.
23 "	Labord,[12] 1862.
23 "	Malshieurat-Legrand,[13] 1841.

These examples prove that there are exceptions to the rule, that tracheotomy for croup is not successful in children under two years of age.

Croup supervening upon the exanthemata is not, as a rule, amenable to tracheotomy. Three cases of recovery after measles are reported by Millard,[14] and Labord[15] has reported one at twenty-three months (see above table) complicated with scarlatina.

Selecting the best individual series of statistics from those repro-

[1] Bull. et Mém. Soc. méd. des hôp. 1867.

[2] Gaz. des hôp. 1867, p. 397. [3] Ibid.

[4] Évenement méd., Jan. 1863. Bull. et Mém. Soc. méd. hôp. 1867, p. 181.

[5] Ibid.

[6] Ibid.; the only successful case out of seven performed during his sojourn at Saint-Antoine, on children under ten years of age.

[7] Ibid. [8] Meigs, Am. Journ. Med. Sci., April, 1849, p. 316.

[9] Präger Vierteljahr. 1859, iv. p. 70. In this case the tube could not be removed definitely until the fifth month after the operation.

[10] Gaz. hebd. 1862, p. 807.

[11] Gaz. hebd. May 27, 1868, p. 348.

[12] There was intercurrent scarlatina in this case. Labord also reports two successful cases at twenty-eight and twenty-nine months respectively. Loc. cit. p. 808.

[13] In this case crico-tracheotomy was performed; no tube was introduced; the edges of the incision into the cricoid cartilage were held asunder by hooks extemporized from pins, and fastened with threads. In another case performed by the same operator, a similar extemporaneous apparatus became displaced the day after the operation, and death from suffocation occurred on the instant. Am. Journ. Med. Sci., April, 1842, p. 470; from Dub. Med. Press, Dec. 28, 1841.

[14] Op. cit. [15] Gaz. hebd. 1862, p. 808.

duced in this paper, all of them exhibiting a success of more than 50 per cent.,[1] most of them results in private practice, we obtain the following table:—

Operator.	No. of Tracheotomies.	No. of Recoveries.
Buck	2	2
Cabot	2	2
Balassa	2	2
Schœllhammer	7	6
Voss (before 1858)	6	5
Trousseau (1854)[2]	9	7
Baudin	4	3
Hodge	4	3
Cruickshank	11	8
Gerdy	6	4
Bardinet	6	4
Perrochaud	3	2
Pancoast (1848)	3	2
Cheever	9	6
von Köpl	17	11
Bourdillat	16	10
Moynier	5	3
Petel	9	5
Richet	9	5
Calvet	23	13
Gay	13	7

Thus affording a very remarkable result in contrast with the entire list.

Many fortuitous circumstances may have been combined in these instances to favor better results than have been obtained in other series of operations. A favorable age in the patient, a good selection of cases, a happy recognition of the proper moment for surgical interference, skilful operation, and assiduous after-treatment may have been the causes leading to such excellent results. These are the elements of success; and it is, in a measure, to assist in a better appreciation of these elements of success that this paper has been compiled.

Attention is invited to four main topics to be discussed in succession. These are:—

1. The indications for the operation;

2. The points of importance in connection with the operation itself;

[1] There are a few other series exhibiting exactly 50 per cent.

[2] His results, 1851–1854, were 24 operations and 14 recoveries. Arch. Gén. méd., March, 1858, p. 259.

3. The after-treatment of the disease and of the surgical wound; and

4. The casualties which prevent recovery.

The Indications for the Operation.

The indication for the operation exists whenever it is apparent that death from suffocation cannot be averted by any other means, it being borne in mind that the very condition suggesting the propriety of an operation in a given case is, in itself, an intimation that should not be disregarded.

It is not only the existence of membrane at the glottis that gives an indication for the operation. There may be persistent spasmodic constriction of the glottis as a reflex manifestation of the inflammatory affection *per se* as in other inflammatory affections of the air-passages in children, or as a reflex influence of the irritation caused by the presence of exudative products in its vicinity; and there may be a permanent paralytic constriction from loss of power in the dilating muscles of the larynx, so that the air cannot pass through the glottis in sufficient quantity, but even presses the relaxed vocal cords towards each other at every inspiration. It has been stated by Niemeyer[1] that he has observed this paralytic condition in croup, on laryngoscopic inspection. It has frequently been observed in the adult, the attendant physical phenomena of inspiration being similar to those of some cases of croup. In either case, a continuance of the paralytic condition, or a threatening persistence or reproduction of the spasmodic contraction would be an indication for the operation, which, under such circumstances, ought to be followed by a successful result, if the blood had not become charged with a poisonous overplus of carbonic acid gas, rendering it unfit for the purposes of nutrition and repair; the more so, as instances are on record of death by laryngeal suffocation, which on examination have not revealed any anatomical or pathological lesion in the larynx.

In a report to the Parisian Société Médicale des Hôpitaux,[2] concerning the pseudo-membranous affections observed in the hospitals during October and November, 1868, several cases of false croup were mentioned, of which one, in the service of Roger, shows how guarded the prognosis should be even in this affection, so much more serious in appearance than in reality. An infant laboring under false croup was attacked with excesses of suffocation sufficiently violent to necessitate tracheotomy, *and it died.*

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[1] Flint's Practice of Medicine, 1868, p. 260.

[2] Gaz. hebd. No 2, 1869, p. 25.

The objection made to tracheotomy, "as being unnecessary when there is spasmodic closure of the larynx, and as useless when false membrane exists in the windpipe without spasmodic closure," is well answered by Dr. Conway Evans, in an article on tracheotomy in croup,[1] by the recital of the following case:—

A girl aged three years: croup treated by the warm bath and by tartar emetic, in spite of which the case progressed from bad to worse until the third day, when, while symptoms of asphyxia were being gradually developed and signs of exhaustion were becoming well marked, the patient suddenly fell back in bed and died, with scarcely a struggle. After death, but before the post-mortem examination, tracheotomy was performed. A mass of false membrane was found, almost filling the larynx, and quite occluding the rima; and extending downwards to the third ring of the trachea; but the *lowest* part of the croupous exudation was just *above* the top of the tracheotomy incision. No false membrane existed in any other part of the trachea.

Even the existence of exudative products in the bronchi, at least in their larger divisions, is not an insuperable contraindication against the operation. Casts of the bronchi have been expectorated in cases which have recovered without operation; proving that they can be detached and expelled. Why not, then, give the patient the advantage of an opening through which surgical assistance can be rendered to facilitate their extrusion? And, what is more to the point are cases, such as that reported by Moneret,[2] in which, although the vesicular murmur was extremely pure and heard everywhere, yet during the operation a false membrane was thrown out which represented the trachea and division of the bronchi. A similar case was reported by Dr. Pepper, of Philadelphia.[3]

Although tracheotomy, when postponed to the last minute, can lead to ultimate recovery only in rare instances, it should be performed, under certain circumstances, even *in extremis*, or even immediately after apparent death; for it has happened, in the experience of several operators, that fleeting life has been recalled under such circumstances by the institution of artificial respiration; though, unless the suffocation has been sudden, death from asthenia usually follows in a few days, or sometimes in a few hours, as a result of the prolonged deficiency in hæmatosis.

Mr. James Spence states[4] that in eight of his operations the patients were *in extremis*, and three of them recovered. Dr. Drysdale,[5] of this city, has

[1] Brit. Med. Journ., Aug. 27, 1859; Am. Journ. Med. Sci., Oct. 1859, p. 549.

[2] H. H. Smith's Operative Surgery, Phila. 1863, p. 270, from Meigs on Diseases of Children, Phila. 1853, p. iii.

[3] Ibid. Summary Trans. Coll. Phys. Phila., iii. p. 106.

[4] Edinburgh Med. Journ., 1860.

[5] Verbal communication.

operated four times, with only one recovery; but the case which recovered was to all appearances the worst of the four at the time of the operation, for it was *apparently dead*, having actually ceased breathing and was pulseless, and required the institution of artificial respiration. Other cases, few in number, it is true, are on record.

Dr. B. W. Richardson[1] has called attention to the fact that the excess of fibrin in the blood may give rise to deposit in the right cavities of the heart, and thus to death by syncope; and he gives directions for the recognition of cases complicated in this way, stating that if symptoms of cardiac obstruction are detected, whether complicated or not with constriction in the windpipe, the operation is worse than useless; and will, of necessity, fail, because there are other fatal influences at work which the knife cannot affect.

Two distinct varieties of impediment to respiration are recognized in croup, apart from paroxysmal spasm, which, though by no means always present, is very frequent in all affections of the respiratory apparatus in children.

In one, there is continuous and usually augmenting dyspnœa with slow asphyxia, air reaching the lungs, but in restricted quantity. There is great general restlessness, but no violent respiratory efforts; there is no sinking in of the tissues above the sternum, and little or none at the base of the thorax. The respirations are frequent and shallow; the pulse small and rapid; the face is swollen; the eyes are listless, and their pupils dilated; the skin is livid, cold, and covered with a clammy sweat; the finger tips are blue at the nails; the mucous membranes of the tongue, gums, etc., are pale; sensation is dulled. Here, the membranous exudation has been thrown out over more or less of the entire bronchial tract, plugging some of the passages or occluding others, so that the air cannot reach the pulmonary vesicles in quantity sufficient to keep up the interchange essential to due hæmatosis. Tracheotomy cannot afford immediate relief to the troubles of respiration except so far as the larynx and trachea are concerned; though it may be of immense secondary benefit; its value in the case being greatly dependent on the condition of system which attends the affection. Many authorities regard this form of asphyxia as a contraindication for tracheotomy; though the operation has occasionally succeeded even when the symptoms have been at their worst.

In the other variety of impeded respiration, the symptoms are

[1] On the Diagnosis of Fibrinous Concretions in the Heart in cases of Inflammatory Croup. Med. Times and Gaz., March 8, 1856, p. 230.

those of more rapid suffocation with paroxysmal apnœa. There is great anxiety and agitation; orthopnœa is marked; there are violent respiratory efforts; the sub-thoracic tissues are deeply indented with each inspiration, and at a later date, the supra-sternal tissues also; inspiration is noisy and stridulous; the pulse is small and frequent; the face is turgid, flushed at first, and cyanosed afterwards; the eyes are suffused and prominent; the cervical veins are swollen; the skin is warm and moist; the mucous membranes are blue; the vesicular murmur cannot be recognized. Here the exudation is limited to the larynx, or larynx and trachea. Cases of this kind are considered favorable for the operation; and on its performance the morbid respiratory phenomena cease.

Intermittent asphyxia is a much less positive indication.

"Guersant[1] has met with children breathing only with violent efforts, and who appeared exposed to impending death. False membranes had been rejected, and no doubt of the nature of the complaint could exist. The necessity of opening the trachea was pointed out to the parents, who objected to the operation. In such cases, emetics, calomel, alum, chlorate of potass were resorted to, and two of these children recovered."

Mr. Henry Smith, in an article on Tracheotomy in Croup and other inflammatory affections,[2] in which he mentions having performed the operation many times in children from eleven months to six years of age, writes: "It is impossible to decide, except in the very last stage of croup, whether the patient will die or not. Almost every practitioner must have met with some remarkable cases of recovery where a fatal result was imminent, and this is the reason why tracheotomy is not used at an earlier period of the disease." He then mentions a case concerning which it had been remarked in consultation that to do it any justice the operation of tracheotomy should be performed at once, but at the same time the case was not so bad as not to leave scope for milder measures. Amendment began, in a few hours, under the continuance of leeches, counter-irritation, and calomel, and the child recovered. He then remarks, "Now, if the operation had been done here, the patient would probably have recovered; but we have the certain proof that in this case, at least, it was not required."

Trousseau,[3] in 1855, wrote as follows, having at that date operated more than two hundred times: "If the diphtheritic infection has profoundly impressed the economy; if the skin, and especially if the nasal fossæ are occupied by the special phlegmasia; if the frequence of pulse, delirium, and prostration indicate a profound poisoning; if the peril is rather in this general condition than in the local lesion of the larynx or the trachea, *the operation should never be attempted;* it

[1] Chaillu, Am. Journ. Med. Sci., July, 1858, p. 253.

[2] Med. Times and Gaz., Jan. 26th; Am. Journ. Med. Sci., April, 1856, p. 495.

[3] Arch. Gén. de méd., March, 1855, and subsequently in his Clinical Medicine, which is essentially the same article with little alteration or additions.

is invariably followed by death: while, if the local lesion constitutes the principal danger of the disease to such a degree that asphyxia is imminent, the infant having but a few more moments to live, tracheotomy is nearly as effectual as if it had been practised three or four hours earlier."

Guersant, basing his opinions on more than two hundred cases operated on between the years 1850 and 1857, considered tracheotomy absolutely indicated whenever voice is extinct; and continuous and increasing difficulty of respiration exists and has lasted two, three, or four hours. He does not consider extreme childhood an insuperable objection, though the chances for recovery are slight. He does not consider pneumonia as a contraindication, as its resolution will be facilitated by the increased freedom of respiration; nor does he consider excessive asphyxia a contraindication, if the difficulty of breathing is permanent, and has lasted continuously at least one hour. He recognizes but one express contraindication, and that is diphtheritic infection or general diphtheritis.[1]

Prof. Stromeyer[2] considers that there are no positive contraindications to the operation; that although it is seldom successful in children under two years of age, or in cases where pneumonia exists, successes do sometimes occur under such unfavorable circumstances; and that therefore the operation is fully justifiable. He believes Baum, of Göttingen, to have laid down the safest indications; limiting tracheotomy to cases in which asphyxia is commencing, where the patient is worn out and sleepy, the skin becoming livid, the lips blue, the extremities cold, the subthoracic tissues sunken in; in which state he saves one-third of his cases. Prof. Roser, of Marburg,[3] operates earlier, when suffocation is threatened, respiration being effected only with the greatest effort, the face being red and covered with perspiration; when there is great uneasiness and anxiety, so that the child throws itself about, tries to leave the bed, and clutches at its attendants for relief; if delayed longer, though breathing may be relieved, the resulting bronchitis cannot be averted.

In discussing this subject, Prof. Heuter[4] reasons as follows: "When, however, the physician follows the course of the disease from day to day, or from hour to hour; when he sees the stenosis of the glottis increase, what symptom gives him the right to invoke

[1] Am. Journ. Med. Sci., July, 1858, from Journ. méd. et chir. Prat.

[2] Handbuch der Chirurgie; Freiburg im Breisgau, 1865, vol. ii. p 361.

[3] Sydenham Soc. Year Book, 1863, p. 276, from Arch. d. Heilk. ii.

[4] von Pitha and Billroth's Handbuch der allgemeinen und speciellen Chirurgie, Erlangen, 1872, vol. iii., Art. Tracheotomie und Laryngotomie, p. 27.

the influence of tracheotomy? One symptom seems of special importance in answering this question. It is the energetic sinking in of the anterior wall of the thorax, especially of the lower end of the sternum. As soon as the want of oxygen in the blood, that is to say, the want of oxygenated air in the lungs of the croupous child, becomes very perceptible, the diaphragm and all the other inspiratory muscles make violent contractile efforts to draw as much air as possible into the thoracic cavity. If now the glottis permits but little air to enter, the diaphragm does not descend as in ordinary respiratory contraction; its central tendon becomes, on account of the limited expansibility of the lungs, a fixed point, towards which its peripheral insertions are forced by the contraction of its muscular fibres. Of these, the insertions of the diaphragmatic muscle on the lower end of the sternum, and on the adjacent costal cartilages are the most movable, and therefore these portions are drawn powerfully inwards by the inspiratory effort. Finally, there is produced at this place, by each inspiration, a deep sulcus into which one can sometimes almost hide the fist. A remarkable sinking in at the jugulum sterni also occurs at each inspiration, because the atmosphere presses forcibly upon the thoracic walls in consequence of the inspiratory rarefaction of the air in the lungs, and the impossibility of a sufficient carriage of the air through the bronchi and trachea. This characteristic depression sets in somewhat later, as a rule, than the depression at the epigastrium, and indicates also a more advanced state of dyspnœa. The well-known abnormal action of the nostrils which always occurs in marked difficulty of respiration, is an additional symptom of the difficulty of the respiratory act. Finally, the general integrity of the respiratory muscles is to be taken into consideration. Their extreme labor always indicates that but little air reaches the respiratory surfaces. I hold the observation of these phenomena more important than that of the harsh and stridulous sounds with which the air passes to and fro through the contracted glottis. The character of these sounds, which naturally are not absent in marked stenosis of the glottis, is nevertheless very variable and indeterminable. A great deal of dyspnœa may go hand in hand with little stridor, and little dyspnœa with great stridor. Observation of the entire respiratory act affords a much safer estimate of the impediment to breathing.

"The coloring of the blood by the retained carbonic acid gas is best examined in the color of the lips. The lips gradually become dark blue, while the cheeks appear, as a rule, very pale and as though swollen by œdema; which strengthens the contrast of the color in the lips to that of the neighboring parts. This symptom

exhibits the altered texture of the blood in the distinctest manner. So, for my part, I consider that the hour for tracheotomy has come as soon as the substernal tissues sink in a marked manner on inspiration, and the blue color appears in the lips. At this period I propose the operation, and if it is declined, death by suffocation follows. The combination of symptoms just described are a safe indication of the greatest danger to life; but I will not deny that cases in which the operation was undertaken by myself are not very numerous, and that I deem it very possible to have erred in estimating the condition of dyspnœa. It may be a mortifying experience to propose an operation, and, after it is declined, to see the case recover, perhaps spontaneously, perhaps under the influence of some empiric remedy. But I believe that, even in such a case, the physician has no reason to reproach himself. A few tracheotomies which were not absolutely necessary for the preservation of life, are not so culpable as neglect of the operation and its postponement to the latest stage. Only think how we govern ourselves in the indications for other operations, by the results of comparative statistics. We feel justified in performing primary amputation in every comminuted fracture with opening into the knee-joint, not because the injury is absolutely fatal, but because we know that without primary amputation a colossal percentage of such cases die, while the percentage is much less if primary amputation is performed. We sacrifice limbs and save human lives. If now, in the afore-described stage of dyspnœa from croup we tracheotomize all our cases, the operation may perhaps be superfluous in ten or twenty cases, but we will save many lives that would have been lost by postponing the operation. Ordinarily, tracheotomy does not entail any permanent injury, and we have to dread only the danger presented in executing the operation and during the healing of the wound. But we will see that we have learned by instituting rational rules to reduce to a minimum the dangers of the operation and those of the progress of the wound."

These views are a fair sample of the opinions held by men who, after considerable personal experience in tracheotomy for croup, remain partisans of the operation. More or less argumentative reasoning of the same kind will be found in most of the essays referred to in different portions of this paper.

Rupture of the trachea from cough in croup, and the consequent production of emphysema, may give an indication for tracheotomy independently of any other condition. Latour mentions a case[1] in which such a rupture occurred between the first and second tracheal

[1] Voss, N. Y. Med. Journal, Jan. 1860, p. 37.

cartilages in a child 2½ years of age;[1] and Dr. Voss, quoting this case, in calling attention to the subject, reports a similar one from the practice of Dr. Gescheidt, of New York, in which the emphysema was stayed by promptly opening the trachea, thereby saving the life of the patient, a girl 4 years of age.

The Points of Importance in Connection with the Operation itself.

The Use of Anæsthetics.—It is a question with some surgeons whether anæsthetics may be safely used in performing tracheotomy for croup. In Germany, Great Britain, and the United States, an anæsthetic is used as a rule; in France the operation is more generally performed without it. The danger of wounding a vessel by an unlucky touch of the knife is not to be underrated; and it is an important matter to control the child's movements, if struggling cannot be averted. If the operation is performed comparatively early, there seems to be little doubt as to the propriety of using an anæsthetic, especially when assistants are few and unskilled. It is generally said to be well borne, not impeding respiration even in some cases of advanced asphyxia. It usually calms the violence of the respiratory efforts and quiets spasm; and thus certainly facilitates the operation. Cases have been narrated, however, in which the symptoms of asphyxia were notably increased by the anæsthetic, so as to render the propriety of its further use doubtful. Anæsthesia need not be pushed to its full extent; for in many instances, especially when respiration has been impeded for a long time, the carbonization of the blood has already produced an anæsthetic influence, which will permit the performance of the operation without much struggling of the patient; indeed, without any, in some cases, the child seeming to recognize the intention of the operation, and submitting to it without a murmur. Kühn mentions[2] an instance in which he performed laryngotomy, without a cry of pain, upon a child whom he had been unable to induce to open the mouth to permit the introduction of an instrument for diagnosis. He has also used chloroform in operating for croup, and has seen great quiet produced after a few inhalations.

Prof. Bœckel, of Strasbourg, in an excellent thesis,[3] based upon 33 personal cases, and a careful study of the entire subject, believes that chloroform should be employed with great prudence; and only

[1] Manuel sur le Croup. Orleans, 1808. [2] Op. cit., p. 147.

[3] De la Trachéotomie dans le Croup, 1867. Reviewed in detail in the Gaz. méd. de Strasbourg, Dec. 31, 1867.

at the commencement, in order to control the agitation. The skin once incised, he considers it useless to continue the anæsthetic.

Dr. F. Howard Marsh writes:[1] "It has been thought that it would be dangerous to give chloroform to a patient partly asphyxiated, because it would render his blood still more unfit for circulation; but I have seen it employed in at least twenty-five cases, and when it has been carefully and slowly given, instead of being mischievous, it has been most beneficial. It is most useful where dyspnœa is recent, and where the child is still vigorous and fully conscious. In such cases the difficulty of breathing is generally in great part spasmodic, and the child is very restless and struggles very much. Here chloroform, by relieving the laryngeal spasm, allows more air to enter the chest, so that the general condition is improved, while there is the great gain that the movements of the trachea are lessened, and the child lies quietly, neither fatiguing himself nor interrupting the operator. Some of the chief authorities in London, Dr. West, Dr. Jenner, and Mr. Paget, as well as those who see or do the operation frequently at the Hospital for Sick Children, Mr. Holmes, Mr. Smith, and Dr. Gee, employ chloroform during its performance. It may, however, be added that it is not required, and should not be given in cases in which the child is so unconscious that he will not struggle."

Dr. Buchanan, of Glasgow,[2] in relating a case of tracheotomy—the twenty-fourth on which he had operated—speaks of chloroform in tracheotomy as follows: "For the first time I gave chloroform in this case, and I was so much pleased with its effect that I would not hesitate to use it in future, although I have hitherto had some doubts of its applicability to tracheotomy. The operation was rather tedious, owing to the great depth of the trachea and some bleeding from small vessels; but I adhered to my rule not to open the trachea till I exposed at least half an inch, which I could see clearly at the bottom of the wound. The chloroform was a great help in this careful dissection." In a subsequent case (the twenty-sixth), related in the same paper, Dr. Buchanan had equally favorable experience of chloroform.[3]

Prof. Roser, of Marburg, recommends chloroform in the suffocative agony, when children are very restless; but considers it inadmissible in asphyxia.[4]

[1] On Tracheotomy in Children; its methods, its dangers, and its difficulties. St. Bartholomew's Hospital Reports, vol. iii. 1867, p. 333. Principally from observations at the Hospital for Sick Children.

[2] Tracheotomy in Croup and Diphtheria; Additional Cases. Glasgow, 1866.

[3] Holmes, Surgical Treatment of Children's Diseases. Phila., 1869, p. 319.

[4] Sydenham Society Year-book, 1863, p. 277, from Arch. der Heilk., ii.

Dr. Voss, of New York,[1] was at first inclined to avoid anæsthesia, and did not use it in his earlier operations; but feeling encouraged to do so by the favorable accounts of others, he at length resorted to it, and had had no cause to regret it. At the time of writing he was disposed to continue to use it.

Dr. P. M. Braidwood says:[2] "Chloroform does not render the condition of the patient any worse as regards the constitutional affection, and it assists the surgeon greatly by keeping the patient quiet. One further advantage I have found to result from the exhibition of chloroform is, that the child by this means is forcibly sent to sleep, and receives refreshing rest, which he has not had for some days previously. This artificially induced sleep is very often followed, after some food has been taken, by a natural slumber." Dr. Braidwood precedes this paragraph by the following remarks: "It is of the utmost importance that tracheotomy should never be performed in a hurry. If this operation is to be of service in the class of cases we have been considering, it can only be useful in a comparatively early stage of the disease; and it is quite useless to thrust a knife hurriedly into the trachea when the child is unconscious and livid. There should be no unnecessary haste shown in the performance of the operation; and, if so, why not relieve pain by giving chloroform?"

The perusal of numerous opinions on this topic has not furnished any views materially differing from those quoted, the majority of authors expressing themselves in favor of the use of an anæsthetic. The emesis which often follows the exhibition of an anæsthetic would in croup—unless, as in one instance I have read of, the matters vomited enter the trachea—be advantageous in promoting the dislodgment of the membrane. Indeed the use of inhalations of ether has been suggested as a means of getting rid of the membrane in the medicinal treatment of croup, and several undoubted cases of success have been reported,[3] and M. Passavant at one time entertained hopes of similar benefit from chloroform.[4] If, as remarked by Bœckel, it is necessary to avoid the pain caused by the incision of the skin, it might be well to anæsthetize the line of incision by a streak of pure carbolic acid, as suggested by Surgeon Bill of the U. S. Army for other operations. Local anæsthesia by freezing might be

[1] Loc. cit.

[2] Tracheotomy in the Treatment of Croup and Diphtheria; Liverpool Med. and Surg. Rep., iii. 1869, p. 14.

[3] Livingston, Amer. Journ. Med. Sci., April 1867, p. 376.

[4] Arch. Phys. Heilk.; N. O. Med. and Surg. Journ.; Amer. Med. Monthly, 1857, p. 48.

dangerous, though, perhaps not, as ice is used locally[1] in Europe, in the treatment of croup. I have heard of some cases of tracheotomy in adults for other affections performed under its influence, but do not know that it has ever been used in croup cases.

The Methods of Operating.—Two principal methods of operating are employed. The best, safest, and most usual method involves a careful dissection down to the trachea. The other method consists in transfixion of the parts and cutting through coverings and windpipe in a single stroke—puncture and incision—by a knife, or puncture by a trocar-like instrument, the tracheotome.[2]

Chassaignac fixes the trachea with a grooved tenaculum passed directly beneath the cricoid cartilage, and then penetrates the trachea by a direct puncture, along the groove, though the skin and subjacent tissues.[3] Isambert operated in this manner in his successful case at sixteen months, and expressed the opinion that it was the preferable method to adopt in very young children.[4] After reading his report he was severely taken to task, for this assertion, by several of his auditors ; among them M. Peter, who stated[5] that he had been present at an operation of this kind, practised with a brilliant rapidity ; but the œsophagus was incised and the tube introduced into it ; the patient dying asphyxiated on the spot. This does not appear to have intimidated Isambert, for he operated in this manner again in his successful case at twenty-two months.[6]

Prof. Trousseau has stated,[7] that Lenoir[8] and Millard[9] sensibly call attention to the danger, in fixing the larynx, of impeding movements connected with the exercise of a function already threatened, and thus running the risk of accelerating asphyxia and death.

Dr. Marsh has stated,[10] that he has known " of three cases in which the canula was not placed in the windpipe at all. In one, it lay in a cul-de-sac in the cellular tissue in front of the trachea ; in another it was thrust also in front of the trachea, and towards the mediastinum, and in the third, it lay by the side of the trachea."

Dr. Thomas Green, in an article on accidents during operations,[11] mentions a case in which tracheotomy had been performed by a

[1] Niemeyer and others.

[2] Many varieties of tracheotomes have been devised. Those who are curious on the subject are referred to Kühn (op. cit.).

[3] Wells, Med. Times and Gaz., Feb. 28, 1857, p. 209.

[4] Bull. et Mém. Soc. méd. des hôp., Paris, 1867, p. 183.

[5] Ibid., p. 193.

[6] Gaz. hebd., May 29, 1868, p. 348.

[7] Clin. Med. London Trans., ii. p. 601.

[8] Da la Bronchotomie, Thèse, Paris, 1841.

[9] Op. cit.

[10] St. Bartholomew's Hosp. Reports, 1867.

[11] Brit. Med. Journ., Dec. 17, 1870, p. 649.

skilful surgeon, on a child with croup; but no relief followed it, and death ensued. The trachea had not been entered; the canula lay in front and close on the rings of the trachea. The plan pursued had been to push a lancet through the coverings into the tube; hence the failure.

Dr. Marshall Hall suggested the performance of the operation, in an emergency, with a pair of pointed scissors.[1] "The integument, being taken up horizontally by the thumb and fingers of the left hand, should be divided longitudinally by the scissors; these should then be promptly forced into the trachea, to the proper depth, and opened horizontally to the just extent; the scissors must then be turned, being kept in their place, and opened in the direction longitudinally; the operator has thus made, in little more than a moment of time, an opening through which the patient may breathe until further appliances can be obtained. Life or death depends meanwhile upon his steady hold of the instrument."

There is no necessity for hurrying the operation, except in a case of emergency that admits of no choice. In the majority of cases there is ample time to proceed carefully and cautiously. Fifteen minutes, more or less, which is a liberal estimate for the difference of time between a hurried operation and a deliberate one, can certainly be spared for tracheotomy, if the patient has an hour or two to live without it. Besides this, an accidental hemorrhage produced in an operation of a minute, may require more minutes to control it than would have sufficed for the most careful operation. Prof. Trousseau, in all his articles, strongly repudiated haste, and speaking on this point during that famous discussion to which allusion has already been made, spoke words to this effect: "A certain surgeon (naming him) has reproached me with operating like a physician and not like a surgeon. Well, he had an opportunity, on one occasion, to operate like a surgeon, and with one stroke of his knife he divided the œsophagus as well as the trachea. Some time afterwards he lost another patient by hemorrhage during his brilliant operation. Since then Mr. ——— has operated more like a physician; and after a while he will become a very fair tracheotomist."

The Arrest of Hemorrhage.—It has been laid down as a rule, by some surgeons, that all hemorrhage from division of vessels during the preliminary incisions should be controlled before the air-tube is opened. It is asserted by many operators, on the other hand, that there is no reason to fear hemorrhage into the air-passages during the operation or immediately after it; that as soon as

[1] Lancet, April 11, 1857; Tanner on the Diseases of Infancy and Childhood, Phila., 1866, p. 343.

an opening is made, so that respiration may be freely established, the venous circulation resumes its wonted course, and the blood from the turgid veins in the neck passes freely into the veins of the thorax, and the hemorrhage ceases at once. That this is often the case there is no doubt; but, on the other hand, the very first inspiration through the artificial opening may draw so much blood into the trachea as to produce complete asphyxia, before the veins are unloaded by the freedom of respiration. In some cases, too, respiration ceases for a few moments after the first inspiration, it seeming as though it took unusual time for the lungs to exhaust the increased supply of oxygen suddenly supplied. An amount of hemorrhage, then, which would be insignificant in the healthy condition, as in many operations for the removal of foreign bodies, may prove fatal here, on account of the serious impediment to respiration already present in croup cases. A deep inspiration, too, may suck the blood into the respiratory surface of the lung tissue itself, and produce suffocation without any blocking up of the bronchial tract. It is best, therefore, unless the emergency admits of no choice in the matter, to follow the advice of those who recommend waiting until hemorrhage has ceased, either spontaneously or by artificial aid, before making the tracheal incision. Bleeding from small vessels can be restrained by holding them for a few moments in the grasp of the forceps, and it is a good plan to secure by spring forceps any vessel that seems likely to give any trouble as it is cut, and when the forceps are removed the bleeding will have been arrested. When the bleeding into the air-passages is profuse, an elastic catheter must be placed in the trachea, and the blood sucked out. Prof. Heuter lays great stress on this employment of the catheter, which he considers one of the most indispensable appurtenances of the tracheotomy case; and he does not think that the use of the mouth can be superseded by any artificial suction apparatus which has been devised. Prof. Roser also states that an elastic catheter should always be kept in the tracheotomy case.

Mr. Arthur Durham,[1] of London, calls attention to the fact that this hemorrhage is more likely to occur in sudden obstruction than in slowly increasing asphyxia, and that in four tracheotomies which he performed (though not for croup), his patients would have died had he waited for bleeding to cease before he opened the trachea. He says: "Until the tube is introduced, a considerable proportion of the blood and comparatively little air will certainly be drawn in by each inspiratory effort through any opening made into the trachea;

[1] The Practitioner, 1869, p. 217.

but when the tube is in position the air passes freely through it, and the blood which has already entered is in great part quickly expelled by the violent expiratory efforts which ensue; and little or no more blood is drawn in, because air enters more readily, and rapidly fills the expanding lungs; and also because, during inspiration, the edges of the tracheal wound and other divided structures are, by atmospheric pressure, kept in more or less close contact with the tube and with one another." "It cannot be too strongly insisted upon, nor too constantly borne in mind, that there is far greater danger of death occurring from want of air than from the presence of blood in the lungs."

Prof. Heuter states that he has several times performed ten crico-tracheotomies (the operation he recommends in croup) one after another without the necessity for securing a vessel; and his practice has always been, not to make the incision into the tube before the bleeding has ceased.

Prof. Roser[1] considers it an important rule not to open the trachea till all bleeding has stopped. He himself, after much experience in the operation, and with practised assistants, had the misfortune to see a child suddenly die from the passage of blood into the trachea, a ligature on the middle jugular vein having been accidentally pulled off. He feels himself bound to oppose the most earnest warning to the carelessness with which this subject is treated by most authors. He is aware of quite a series of cases in which children have perished on the operating table in the same manner; and he has become convinced, from experiments on rabbits, of the reality of the danger which arises from sudden coagulation of the blood in the bronchial ramifications.

Some operators are so fearful of hemorrhage that they have endeavored to open the trachea by cauterization. Kühn states[2] that the proposition was suggested by Le Clerc (in the *Revue méd.*, v. 1851), and that Dujardin opened the trachea without hemorrhage in this way, in a case of œdema of the larynx, by the use, during two days, of a caustic paste. This method would be too slow for croup or any other case of emergency, even were there no other objection to it. Dujardin's case of œdema of the larynx must have been a very accommodating one, or the effusion must have been controlled by the counter-irritation. Amussat, in 1870, used the galvano-cautery in a case of foreign body.[3] It has also been used by Verneuil,[4] Voltolini,[5] and

[1] Loc. cit.

[2] Op. cit., p. 150.

[3] Lancet, May 18, 1872, p. 688; Bull. de Thérap, 1872, p. 472.

[4] Bull. de l'Acad., 2ème sér. i., 1872, p. 299; Bull. de Thérap, 1872, p. 472.

[5] Berlin klin. Woch., 1872, ix. 41. See, also, Arch. Gén, June, 1872, p. 734-6; Gürlt's Jahresbericht für 1863-1865 in Arch. für klin. Chir., 1867, pp. 559-566.

others. Prof. Bardeleben is inclined to think well of the galvano-cautery.[1] MM. de Rause and Muron have proposed the actual cautery.[2] Chaissaignac has proposed the écraseur;[3] and Guérin a subcutaneous tracheotomy.[4]

One might picture to himself an energetic practitioner summoned at midnight to perform tracheotomy, and hurrying with his patent chloroform inhaler, his magneto-electric machine, his pneumatic aspirator, his galvano-cautery, and his bellows for artificial respiration!

A canula surrounded with a tubular rubber obturator, as devised by Trendelenburg,[5] might be of great service, in cases of severe hemorrhage, to prevent the flow into the windpipe. It has been used for this purpose with great satisfaction in operations for other affections.

The Incision into the Windpipe.—The operation most frequently practised is vertical incision of the trachea in the median line for a space comprising two or more of its rings. Some surgeons incise the trachea as high up as possible, others as low down as possible; some divide the cricoid cartilage; others the cricoid cartilage and a ring or so of the trachea; some excise a portion of the anterior wall of the trachea, the incision being elliptical, oval, rectangular, or diamond-shaped; others excise the anterior wall of the cricoid cartilage, with or without preservation of its perichondrium. Division or excision of the crico-thyroid membrane is rarely practised in croup cases. The majority of operators introduce a rigid curved tube or canula of some sort into the trachea, whether incision or excision has been practised. Others dispense with a tube altogether, and, if a portion of the trachea has not been excised, resort to some other contrivance, such as hooks or ligatures, to keep the artificial opening patulous.

The recommendation of cutting a piece out of the trachea is attributed to Mr. Lawrence (or Laurence), of London. This operation was successfully practised by Mr. R. Carmichael, of Dublin, in 1820[6] and in 1823,[7] on adults; in the latter instance he removed with scissors a diamond-shaped section comprising two tracheal rings and three interspaces, and found the delicate pair of scissors he employed a better instrument for the purpose than the knife.

John Andree,[8] of London, in 1782 found it necessary to dispense with the use of the tube. His operation is described in his own words as follows:—

"The child being laid on his back, and kept as quiet as his great restless-

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[1] Lehrb. der Chir., 1872, iii. p. 496.

[2] Gaz. méd., 1873, 48. Translated in Phila. Med. Times, Oct. 25, 1873, p. 54.

[3] Med. Times and Gaz., May 25, 1872, p. 604. [4] Ibid.

[5] Die Tamponade der Trachea, Berlin. klin. Woch., 1871, No. 19. Arch. klin. Chir., xii. p. 121.

[6] Trans. King's and Queen's Coll. Phys. Ireland, 1820, p. 170.

[7] Ibid., 1824, p. 311, with illustration of incision.

[8] Farre, Med.-Chir. Trans., iii. 1812, p. 336.

ness in struggling for breath would admit of, I commenced the operation by a straight incision from the thyroid gland towards the sternum, about one inch and a half in length. I then cautiously laid bare the anterior part of the trachea, without any material hemorrhage or difficulty, except what arose from the child's struggles, and then made a small transverse incision, or rather puncture, through the membrane which connects the second and third annular cartilages, and then a similar incision between the fourth and fifth cartilaginous rings; the respiration was immediately relieved. I now proceeded, according to the rules laid down by the most approved authors, and as myself had taught in anatomical lectures, to introduce a silver canula into the trachea through one of the orifices. It instantly produced a most violent and incessant cough, until the instrument was withdrawn. A hollow bougie being introduced, produced the same effect. I then contented myself with dressing the wound superficially, cutting an orifice in the plasters to correspond with the openings into the trachea, and covering the wound with a piece of gauze laid loosely on the neck."

Mr. Thos. Chevalier,[1] in his successful case in 1814, "exposed the trachea just below the cricoid cartilage, and divided two of the cartilaginous rings vertically, cutting afterwards transversely in the interstice between them." In concluding his account he states: "It would also follow, that the introduction of a canula or tube into the trachea after the operation, for the sake of securing the passage of air, is of less consequence than has been usually supposed, and might even be better omitted, as the presence of an extraneous body must irritate the internal membrane, and would thus be likely to increase that secretion of mucus from an accumulation of which the principal danger is to be apprehended. In the instance which I have related, I found no necessity for a tube, though I am sure little or no air entered the wound."

This patient was a boy, seven years of age, who had discharged false membrane. The crucial incision in the tracheal wall permitted egress of the exudative products; while respiration was carried on mainly through the natural passages.

Prof. Pancoast, of this city, performed three tracheotomies for Dr. J. F. Meigs, in 1848,[2] in all of which he cut out an elliptical portion of the anterior wall of the trachea, dispensing with the use of a tube; and two out of the three recovered, one of the patients being but nineteen months old.

Dr. Marshall Hall, in a lecture on laryngismus and tracheotomy delivered before the class at the Pennsylvania Hospital in this city, in April, 1853,[3] exhibited a compressible wire dilator which he proposed as a substitute for a canula, and which he called a tracheotone, or trachea stretcher, because he proposed, after incising the skin, to simply pierce the trachea with a pointed, tapering instrument, introduce the tracheotone compressed, and let it stretch the tissues in dilating. The tissues, he asserted, would readily yield to stretching. This instrument was never used much, and is generally believed

[1] Op. cit., Med.-Chir. Trans., 1816, p. 152.

[2] Am. Journ. Med. Sci., April, 1849, p. 307.

[3] Reported in Am. Journ. Med. Sci., July, 1853, p. 55.

to be hazardous, on account of the danger of the wire cutting the tissues, and wounding vessels. In a discussion upon a paper on Tracheotomy in Diphtheria, by Dr. George Buchanan, of Glasgow, Dr. Davey stated that he knew of two deaths which were attributable to the use of Dr. Marshall Hall's tracheotone;[1] and Mr. Arthur Durham, in his very excellent paper on Tracheotomy, alludes[2] to a fatal case reported in the *Medical Times* for 1859, and designates it as "clearly due to the use of an instrument, which to mention is to condemn." A vessel had been cut in the withdrawal of this instrument, producing fatal hemorrhage.

In a case operated upon by Dr. Henry J. Bigelow, of Mass.,[3] he cut a piece out of the trachea on the third day after the operation, on account of the mechanical interference of the tube to the discharge of false membrane; and on the next day introduced two pieces of annealed wire to act as dilators; and these were used to keep the wound open until the child's death, which occurred on the twelfth day, from pneumonia and debility.

Dieffenbach cut out a four-cornered piece with a scalpel; and Blasius, in a child four years of age, an elongated strip, three lines long by two broad.

Dumreicher proposed a dilator modelled on Snowden's eyelid speculum. Linhart states[4] that it is not well borne, and recommends an elastic band with metallic hooks to keep the lips of the the incision apart. Heuter says[5] that this dilator of Dumreicher will produce necrosis if used for any length of time.

Prof. Brainerd, of Chicago,[6] avoids the use of the canula by making a valvular or flap incision into the trachea. His directions for making this incision are: "Having denuded the trachea, insert a small suture needle, armed with a ligature, beneath two of its rings. Withdraw the needle, and, drawing gently on the thread, make a semicircular incision on one side, so as to form a valve, readily opened by drawing on the thread. The opening thus formed can be kept patent or be allowed to close at will." It is evident that when the flap is left to itself, the parts are acted upon somewhat as in the manner after Chevalier's crucial incision. Brainerd further states that "In tracheotomy for croup, the prolonged sojourn of the tube has been considered, by the most eminent surgeons, as a cause of the pneumonias which so frequently are the cause of death."

Guillou proposes[7] a sort of eyelet of flexible ivory, or of lead, to prevent the irritation and other deleterious consequences of the canula.

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[1] St. Andrew's Medical Graduates' Association Transactions, 1867; Am. Journ. Med. Sci., April, 1869, p. 483.

[2] Practitioner, 1869, p. 217. [3] Am. Journ. Med. Sci., July, 1853, p. 81.

[4] Compendium der Chirurgie, Operationslehre, Wien, 1856, p. 49. Heuter, op. cit.

[5] Op. cit.

[6] Chicago Med. Journ., March, 1859; Am. Journ. Med. Sci., July, 1859, p. 291.

[7] Réflexions sur l'operation de la trachéotomie dans le cas de croup. Modification à apporter au procéde ordinaire. Bull. gén. de thérap., Sept. 1869, p. 267–272.

Nélaton[1] loosened the perichondrium from the cricoid cartilage, leaving it in connection with the crico-thyroid membrane; and then excised a portion of the cartilage. If a tube were employed, this would hardly be necessary in croup cases, for the cricoid cartilage in children yields ready entrance to the canula.

Levis, of Philadelphia, in his successful case, did not use a tube.[2]

The objections urged against dispensing with the tube are that the swelling of the soft parts is often so great as to prevent free access of air to the artificial opening; that the movements of the trachea may draw the opening in that structure away from the superficial wound, unless the latter is very large; and that the formation of granulations may take place so rapidly as to close the defect in the trachea before the favorable course of the disease has overcome the occlusion of the larynx. Whenever an artificial opening has to be maintained for more than a very few days, the use of the canula seems to be indispensable.

The tubes usually employed are made of silver; but some surgeons prefer them made of hard rubber. Perhaps the use of a leaden tube for the first few days, or until the fistulous track is hardened, might prove less deleterious to the parts than either hard rubber or silver.

Prof. Roser,[3] as soon as the first expectoration is over, after opening the trachea, passes a ligature through each edge of the tracheal wound; this is not tied, but only twisted a little, and then fastened on each side with adhesive plaster. The operator thus has full command over the trachea, and can readily dilate the wound; a circumstance that much facilitates the insertion or the change of the canula. He keeps the ligatures in for three or four days; and has not seen any injurious effect from them, in an experience of some forty cases.

Prof. Trousseau urges that the incision be made in the trachea, and that the cricoid cartilage and crico-thyroid membrane be spared; arguing that, if, as sometimes happens, the canula is to remain several weeks in the wound, it will produce partial necrosis of the cartilage.

Prof. Heuter, of Greifswald,[4] strenuously urges the division of the cricoid cartilage, from below upwards,—but avoiding the conoid ligament,—as the safest operation in children; recommending the subsequent division of a tracheal ring or two, in case the opening prove insufficient. His arguments are that this locality is freer than any other from all anomalous anatomical complications; and that it permits the direct withdrawal of false membrane from the glottis. He has performed this operation many times, and has never encountered any untoward results referable to the division of this cartilage. He has several times performed ten crico-tracheotomies in succession without any necessity to secure a single vessel, and

[1] Panas; Gaz. des hóp., 1871, No. 117.
[2] Verbal communication.
[3] Op. cit., p. 277.
[4] Op. cit.

it has always been his practice not to make the incision before the bleeding had ceased.

The moment of making the incision is a very important one. The usual method is to stab the trachea, as it were, with the point of the knife, and then to cut upwards or downwards as the case may be, or to remove the pointed knife and complete the incision with a probe-pointed bistoury. Care must be taken in penetrating the trachea that the force of the movement does not carry the knife too far, so as to wound the posterior wall, or make a counter-opening into the œsophagus. More than one case of this kind has already been mentioned on the authority of Trousseau, and others; and the possibility of the accident is alluded to by a number of authors.[1] Sudden suffocation may ensue, with immediate death, from the flow of blood into the bronchial tract. Several cases of this kind are mentioned by Kühn[2] from the observations of Trousseau and others. When any danger of this kind is to be apprehended, it is customary to raise the child up, as soon as the incision is made, so as to prevent the blood from running down the trachea; and if this does not suffice, a finger is placed over the wound. Bleeding into the trachea may occur also, though in much more limited quantity, from vascularity of the divided mucous membrane; or if the cricothyroid membrane is incised, which is rarely done in croup cases, from division of an artery in its substance. Prof. Billroth lost a case[3] in an attempt to dilate the wound some hours after the operation, in order to return the canula; though the cut he made was exceedingly small.

Another untoward complication may arise, in cases where false membrane is present in the path of the knife, by pushing it over against the posterior wall of the trachea. Heuter[4] states that he has noticed, in several instances where false membrane existed upon the anterior surface of the cricoid cartilage or the trachea, that the point of the knife did not penetrate the false membrane, but merely loosened it and pressed it backwards, occluding the tube, and in this way rendering suffocation imminent. The forced respiration of the suffocative paroxysm would, as a rule, he says,

[1] Kühn, op. cit., p. 149, cites cases of this kind from Barthez; also one from Bacher, in which it is not distinctly stated whether a communication between the trachea and the œsophagus, found after death, was made during the operation or not. Glas (Upsula läk för. förhande, Bd. v. p. 37; Virchow's Jahres. med. Wiss., 1870, Bd. ii. p. 369) describes a tracheotomy in which the trachea was transfixed and cut through.

[2] Op. cit., p. 151.

[3] Arch. klin. Chir., 1869, p. 192.

[4] Op. cit., p. 46.

tear the membrane loose and force it out; but he has never waited for this occurrence, which might be impossible in moribund children, but he has introduced an elastic catheter to tear the membrane loose, and blown into it to excite cough or supply air. Trousseau[1] records a very illustrative case in which the false membrane, being torn by the introduction of the canula, was impacted by the instrument into the trachea, so as to obstruct the passage of air completely. A fatal instance of this kind occurred in the practice of Dr. Jacobi, of New York,[2] and is related by him in his admirable article on Croup, in which, as he graphically expresses it, "the child was strangled in the attempt to save her life."

Another element of danger is the descent of loosened membrane upon the bronchi. This element of danger, says Heuter,[3] is not to be underrated. As a rule, the false membrane is half-incised, half-torn by the point of the knife; and large fragments may become loose enough, partly by their mere weight, and partly by the suction power of the inspiratory current, to reach the bifurcation. He has seen several such cases on the operating table, and has always overcome them by aspiration through the catheter. He believes that many cases of death from suffocation which other operators have encountered have been due to this cause.

Inasmuch as this point has not received a great deal of attention from other authors, the question naturally arises, whether Heuter's method of incising the cricoid cartilage is not more apt to bring his knife in contact with false membrane, in many instances, than an incision practised some distance below?

In pursuing this theme Heuter calls attention to the dangers of confounding the asphyxia brought about by obstruction of the air-passages with membrane and blood, with the apnœa which sometimes supervenes immediately on opening the trachea. When the stream of air rushes free into the lungs of the suffocating child, breathing is sometimes suspended for a moment. This causes the operator a good deal of anxiety when he sees it for the first time; but it is void of danger, and he soon learns to distinguish apnœa from asphyxia.

Heuter strongly urges in every operation for membranous croup, that, immediately after the opening is made into the trachea, an elastic catheter (from No. 8–12) should be introduced down to the bifurcation, and suction be made, as first recommended by Roux. The membrane and blood is thus drawn into the eyes of the catheter,

[1] Op. cit., p. 601–2.
[2] Am. Journ. Obstet., 186[2], p. 59.
[3] Op. cit.

and when the latter is withdrawn the obstructing contents come with it. Even its simple introduction and withdrawal will cause the discharge of some of the membrane, and also of some of the blood; and as there is some personal danger in aspiration, this may suffice in slight cases. But when the respiration remains unfreed after the opening is made, or asphyxia supervenes, aspiration becomes necessary, for everything points to an obstruction low down, for the prompt relief of which there is nothing so useful. He says one soon learns to avoid receiving the contents of the catheter in the mouth. A small glass globe can be attached to the catheter to receive the contents. He has tried the suction syringe, and the compressed rubber ball recommended by Stromeyer, but has not been satisfied with their action. The mouth enables him to appreciate the resistance; and to his fearless use of it, he attributes his good fortune in never having lost a patient on the operating table.

Should artificial respiration be required, Heuter recommends again the use of the catheter to blow air into the lungs; while expiration is to be effected by manual pressure on the hypochondrium, the movements being made alternately, and in the rhythm of normal respiration. Prof. Roser[1] also recommends that there should always be an elastic catheter in the tracheotomy case; for he thinks that nothing promotes so conveniently and innoculously the discharge of false membranes, and excites respiratory movements, as the motion up and down of a catheter; such an irritation being especially required where asphyxia already exists.

The incision being made into the trachea, its edges should be held apart by hooks or other contrivances, and search be made for false membrane as in a case of any extraneous foreign body. This is a point discussed by very few operators, most of whom, judging from their published records, introduce the canula as soon as possible. If membrane is removed by forceps, by aspiration through a catheter, or simply by cough mechanically excited, before the canula is introduced, it must be a great gain; because the membrane can otherwise be discharged only through the tube, against or within which it may become lodged in one of the paroxysms of cough. Cases have been recorded[2] in which large portions of tracheal and bronchial membranous exudation were removed through the tracheal orifice. If the trachea is cleared of all the membrane it contains at the time of the operation, it is fair to infer, that, what with the subsidence of muscular exertion in breathing, due oxygenation of the blood, and refreshing slumber, the general

[1] Op. cit., p. 277.

[2] One by Moneret is already alluded to in these pages.

state of the system will be so far improved as to give an interval of many hours at least, before the exudation again accumulates in obstructing quantity.

The false membrane is usually readily detached, often by the force of the cough alone; in some instances, however, it is exceedingly adherent, requiring considerable effort to detach it.

In one of the cases operated upon by Prof. Pancoast,[1] "the inner circumference of the trachea was found lined with a false membrane of much density and toughness. This was so tough that in attempting to detach it from the side next the larynx by pulling on it with the forceps, the larynx was drawn downward before the membrane broke."

The Canula.—The canula usually employed at the present day is a modification of the double tube originally devised by George Martin[2] from the suggestion of one of his friends in 1730. As modified by Prof. Trousseau, the inner tube projects a little beyond the terminal extremity of the outer one, so as to free the latter when the former is removed or inserted. The proximal extremity of the outer tube should be suspended by movable joints in a perforated plate to be fastened upon the neck by means of tapes or elastic bands tied behind. This arrangement, by allowing the tube to adjust itself to the movements of the trachea, avoids pressure against the mucous membrane to some extent; and, thus far, prevents ulceration of the trachea; a serious complication which sometimes attends a prolonged use of the tube, though it sometimes occurs within 36 or 48 hours. The size of the tube should be as large as can be conveniently employed without touching the walls of the trachea. Trousseau[3] thinks that the canula should be of larger calibre than the glottis. Others recommend that it should be about as large as the calibre of the cricoid cartilage, which is considerably less than that of the trachea, in some cases much less. By having a number of tubes of graduated sizes the nicety of adjustment may be attained, whatever may be the age of the child; the same sized tube employed promiscuously for all cases, as is the habit, will not always be well adapted to the case in hand. Too short a canula may be coughed outside the trachea, rendering the patient liable to become asphyxiated in a few moments by its pressure externally. Three times an accident of this kind occurred in Trousseau's practice.[4]

In order to permit the easy introduction and withdrawal of the inner tube, the canulas are made in the form of a segment of an ellipse, or in that of a circle, a form in which the terminal extremity

[1] Am. Journ. Med. Sci., Apl. 1859, p. 315. [2] Philosophical Transactions, 1736.
[3] Op. cit. [4] Clin. med., ii. p. 604.

is apt to graze the anterior wall of the trachea; and to avoid this, the terminal orifice is to be bevelled off from before backwards. Dr. Arthur Durham, of London,[1] has devised a canula turning into the trachea at right angles, and capable of being set, by means of a movable collar, at any distance from the surface. This avoids contact with the walls of the trachea; but it necessitates the use of a jointed or lobster-tailed inner tube, which is likely to necessitate very frequent removal, an operation sometimes even difficult, in certain instances, from presenting so many projecting points for the detention of mucus, pus, blood, and other products.

Dr. Fuller, in a paper[2] read to the Royal Medico-Chirurgical Society of London, January 27, 1857, recommended that both tubes be of the same diameter throughout, and that the outer one be divided longitudinally into two blades, flattened towards their inferior extremity so as to come into close apposition, and to admit of easy introduction into the trachea; being made to open like the blades of a bivalve speculum, and admitting, when fully expanded, an inner tube of uniform diameter throughout. This arrangement, he claimed, could not only conduce to keep the inner tube clear of mucus, but would render serious obstruction to the respiration well nigh impossible, inasmuch as, if the inner tube were to be clogged in any way, and the extremity of the outer canula also were to be choked with mucus, the chink existing between its expanded blades would provide a free passage of air immediately on the withdrawal of the inner tube. This tube has not won the approval of many operators.

Bourdillat, of Paris, more recently[3] contrived a more elaborate outer tube on the same principle, which has proved more efficient; and which will often prove of great service[4] in dressing tracheotomy wounds, whenever any serious difficulty is presented in replacing the ordinary canula.

The canula is confined to the neck by tapes or elastic bands attached to the plate.

The surface of the skin should be protected from the discharges which take place through the canula, by means of a piece of oiled silk or rubber cloth into which a hole has been cut for the passage of the canula, the whole having been prepared before the introduction of the tube. Beneath this, if desired, a greased rag may be placed to prevent its becoming plastered to the skin. The wound is brought together by adhesive strips merely, sufficient room being

[1] The Practitioner, 1869.

[2] Med. Times and Gaz., Feb. 7, 1857; Am. Journ. Med. Sci., Apl. 1857, p. 525.

[3] Gaz. hebd., 1868, p. 154.

[4] Sanné, op. cit.

allowed below for drainage. Experience has shown that sutures are not well borne, and are often cut out by the strain exerted on them in the paroxysm of cough. Sometimes cases do very well without any dressing whatever.

The introduction of the tube is facilitated by holding the lips of the tracheal incision apart either by tenaculum, forceps, blunt hooks, or special dilators; and still further by the temporary use within the tube of a conducting gum catheter or a special piloting blunt trocar, or a bit of gum bougie, so as to present a solid tapering extremity which is more readily manipulated. Dr. Guersant, who modified Trousseau's dilator by substituting rectangular blades with plane extremities, and opening by pressure upon the handles, states,[1] as the result of personal experience in more than three hundred tracheotomies which he has performed, that he believes the best method is to use a dilator, and the elastic bougie as a conductor. Laborde further modified this dilator by attaching a third blade, but, though a very admirable instrument, it is believed by Guersant and others to possess no special advantages. Mr. John Couper[2] inserts a flexible rod of gutta-percha into the trachea, and then runs the tube down on it, when there is any difficulty in introducing the latter.

The final removal of the canula is usually made at a period varying between the 5th and 9th day after the operation. In occasional and rare instances it may be removed as early as the end of the first day; and in other instances it cannot be dispensed with for a number of weeks, or a number of months. In Jacobi's 13 successful cases,[3] the canula was permanently removed as follows:—

On the 17th day,	in 2 cases.	On the 42d day,	in 1 case.
" 18th "	" 1 case.	" 44th "	" 1 "
" 20th "	" 1 "	" 46th "	" 1 "
" 27th "	" 1 "	" 54th "	" 1 "
" 29th "	" 1 "		—
" 30th "	" 1 "		13 cases.
" 35th "	" 2 cases.		

In four of these cases the protracted use of the canula was due to polypoid excrescences at the margins of the tracheal wound.

In Steiner's cases the canula was permanently removed as follows:—

[1] La chirurgie des Enfants, Paris, 1864–7, p. 42.

[2] London Hosp. Rep., 1868; Brit. and For. Med.-Chir. Rev., July, 1869, p. 41.

[3] Am. Journ. Obstet., May, 1868.

On the 10th day, in	2 cases.	On the 34th day, in	1 case.
" 17th " "	1 case.	" 35th " "	1 "
" 20th " "	3 cases.	At the end of one year and three months . . in	1 "
" 21st " "	2 "		—
" 25th " "	2 "		18 cases.
" 28th " "	4 "		
" 30th " "	1 case.		

Sanné[1] gives the following dates of the final removal of the canula in 108 cases :—

At the end of the 1st day, in	1 case.	At the end of the 16th day, in	2 cases.
" " " 3d " "	3 cases.	" " " 17th " "	2 "
" " " 4th " "	7 "	" " " 20th " "	2 "
" " " 5th " "	14 "	" " " 23d " "	1 case.
" " " 6th " "	16 "	" " " 24th " "	1 "
" " " 7th " "	10 "	" " " 25th " "	1 "
" " " 8th " "	14 "	" " " 30th " "	1 "
" " " 9th " "	5 "	" " " 32nd " "	1 "
" " " 10th " "	8 "	" " " 34th " "	1 "
" " " 11th " "	3 "	" " " 35th " "	1 "
" " " 12th " "	3 "	" " " 45th " "	1 "
" " " 13th " "	5 "	" " " 126th " "	1 "
" " " 14th " "	1 case.		—
" " " 15th " "	3 cases.		108 cases.

In Max Müller's[2] 15 successful cases, the tube was removed definitely :—

On the 13th day.	On the 69th day.
" 15th "	" 70th "
" 25th "	" 79th "
" 27th "	" 105th "
" 42nd "	" 112th "
" 44th "	" 120th "
" 51st "	and 203rd days resp'ly.

A most exceptional series. He mentions that in one of these cases febrile phenomena reappeared on the 19th day after the operation ; followed, three days later, by the expectoration of a tubular cast of membrane two inches in length, bifurcated at one extremity and bearing an impression of the primitive bronchi.

The causes which prevent the early removal of the canula, are spasm, inflammatory products in the air-passages or in the wound, and diphtheritic paralysis.

The spasmodic condition is sometimes independent of any appreciable cause. Sometimes it is due to fear of suffocation, on the

[1] Op. cit., p. 30.

[2] Arch. klin. Chir., 1871, p. 448.

part of the patient, requiring great circumspection, patience, and care to overcome. Millard relates a case in which the child, though able to breathe without the tube, would not lose sight of it for a minute, and became subject to a suffocative paroxysm if a threat was made, in pleasantry, to take it out of the ward. It became necessary to let him carry it around his neck like a watch chain. Blachez[1] recounts a case of a child who, after having for six weeks resisted all attempts to dispense with the canula, passed an entire day without his tube. While playing, he pinched his finger in a doorway, and the emotion produced by this accident brought on a paroxysm of suffocation which proved fatal in a few minutes. A patient of Bergeron[2] was unable to dispense with the canula for more than a few minutes. At the end of forty days he was able to pass a day and night without it, but had such a severe paroxysm of apnœa the next day that it was necessary to practise tracheotomy anew. From this time forward he could not be deprived of his canula for more than a quarter of an hour each day. On the 154th day he died of a broncho-pneumonia, the sequel of measles. The autopsy did not reveal any lesion which could explain the obstacle to respiration. M. Bœckel reports a case in which he had to perform tracheotomy a second time, on account of spasm after the removal of the tube, on the 19th day. The canula was definitely removed on the 11th day after the second tracheotomy, the 31st day after the first tracheotomy. Dr. Rouzier-Joly[3] relates a case in the person of his own son, in which the tube could not be removed for fourteen months, on account of spasm. Cauterization of the deep parts of the wound was of great benefit.

M. Paris relates[4] the following case: J. B., æt. 5½ years, had a severe attack of croup in Nov. 1865, for which M. Paris performed tracheotomy. Recovery was complete on the 14th day. On the 32d day, after many temporary removals, the canula was taken out, and the wound allowed to heal. Respiration gradually became so difficult, that in two days it had to be replaced. Other attempts were made at three and four months; but still without success. The boy was taken to Paris, and seen by M. Trousseau, who stated that he had met with several similar cases, in one of which the canula had to be retained for five years, and yet eventually a cure was completed. M. Marjolin confirmed this opinion. M. Ozanam made a

[1] Sanné, op. cit., p. 145.

[2] Sanné, op. cit., p. 147, and in detail (obs. 28) p. 256.

[3] Croup, trachéotomie, étouffements provoqués par l'ablation momentanée de la canule. Gaz. des hôp., 1867, No. 75, p. 297.

[4] Gaz. des hôp., April 13, 1867; Am. Journ. Med. Sci., Jan. 1868, p. 273.

laryngoscopic examination, but after twenty examinations, assisted by the little patient with good will and courage, could discover nothing, but that the larynx and vocal cords were healthy. At the date of the report, sixteen months after the operation, the boy was healthy, but was still wearing the canula. During the day he closed it with a plug, which he had to take out at night. The curious point is, that although he could breathe quite well with the canula completely plugged, he could not breathe when it was removed.

Dr. Ehrmann, of Strasbourg, presented to the Société Médicale du Haut-Rhin, at its session, May 10th, 1868,[1] a little girl 4 years of age, whom he had tracheotomized for croup, on June 14th, 1867, and who could not dispense with the tube, the removal of which was followed by suffocative phenomena. Dr. Ehrmann had encountered two other cases of this nature, mentioned in the thesis of Dr. Edouard Bœckel. The explanation of these phenomena seemed to reside in the fact that the laryngeal muscles had lost the habit of contracting harmoniously for the needs of respiration; the patients being somewhat in the condition of those with paralysis of the vocal cords.

The presence of false membrane in the larynx may retard the removal of the canula. False membranes are seldom observed longer than a week after the operation; sometimes not after the first day; occasionally for a much longer period. One or two instances of the latter kind are incidentally alluded to in this paper; and Sanné reports one in which false membranes appeared until the thirty-second day, having necessitated a second tracheotomy fourteen days previously.

Tumefaction of the mucous membrane of the larynx may be another cause. Sanné[2] states, that in two cases in which the canula could not be removed without embarrassment of respiration, threatening suffocation, the patients died of broncho-pneumonia; and the autopsy revealed that the tracheal mucous membrane was red and hypertrophied, forming, at the level of the vocal cords, prominent projections which obstructed the glottis. In another case,[3] there was a veritable œdema of the glottis, a very rare occurrence in children.

Barthez observed, at Sainte-Eugénie Hospital,[4] a case of œdema of the glottis occurring without known cause and terminating fatally in an access of suffocation which did not afford time to perform tracheotomy.

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[1] Gaz. méd. de Strasbourg, Aug. 10 1868, p. 177.

[2] Op. cit., p. 153.

[3] Op. cit., recorded in detail at p. 208.

[4] Gaz. hebd., 1869, No. 2, p. 25.

The presence of exuberant granulations or polypoid excrescences in the track of the wound or in the larynx itself may prevent removal of the canula. Dr. Jacobi[1] states that in four of his cases of recovery, removal of the tube was rendered impossible by "polypoid excrescences, sometimes numerous, of the size of a pin's head to that of a pea or more, originating on the margin of the tracheal wound, in one case on the lower portion of the sore larynx itself. It required a great many applications of nitrate of silver, or subsulphate of iron, to destroy them. Their disappearance would instantly relieve the symptoms, and allow of the final removal of the tube from the trachea."

Steiner[2] mentions luxuriant granulations at the edge of the tracheal incision, forming a tongue-shaped projection within the respiratory tube.

M. Bergeron[3] reported a case in which death from pneumonia occurred on the twenty-third day, after numerous ineffectual attempts to remove the tube. The autopsy revealed the presence of a pedunculated laryngeal polyp about one centimetre above the incision in the trachea. It is doubtful if this polyp had anything to do with the croup.

Dr. Gigon, of Angoulême, has published[4] a case in which the canula was removed on the fifteenth day, but respiration did not become re-established satisfactorily. Paroxysms of suffocation supervened, necessitating a second tracheotomy forty-five days after the first. There was then seen, in the neighborhood of the tracheal cicatrix, some roundish, red, movable bodies, the size of peas, which obstructed the calibre of the tube; and they were excised. The canula was then removed on the third day, and there was no further difficulty.

Catarrhal affections of the air passages will retard the removal of the canula, on account of the difficulty of expulsion for the products of secretion.

Finally, *diphtheritic paralysis* may render the larynx insubservient to the purposes of respiration, and necessitate the prolonged use of the canula.

The cause of difficulty in removal of the canula being recognized, the appropriate treatment, medicinal and surgical, suitable for the same condition under other circumstances, would be employed in cases occurring after tracheotomy for croup.

[1] Am. Journ. Obstet., May, 1868. [2] Op. cit.
[3] Union méd., 1868, p. 624; Gaz. méd., 1869, p. 253.
[4] Sanné; op. cit., p. 154; Union méd., 1862, p. 272.

The period of death after tracheotomy for croup varies, as we see from the tables presented, from a few moments to several months. Mr. Spence[1] states that, as a general rule, death occurs in croup proper two, three, or four days after tracheotomy, and in cases of diphtheria two or three weeks after the operation.

Cicatrization of the Wound.—The canula being permanently removed, the wound, as a rule, gradually contracts, and cicatrization is completed, without interference, within a few days. If cicatrization progresses favorably, the prognosis is good as to ultimate recovery; if it is retarded, it indicates, in the absence of local disease, the approach of some complication. Exuberant granulations are repressed with nitrate of silver. If cicatrization is too slow, the edges of the wound may be touched with some gently stimulating application. Sanné speaks well of carbolic acid, one part in a hundred. The following table from Sanné[2] is instructive:—

DATE OF CICATRIZATION IN SIXTY-EIGHT CASES.

At the end of	9	days	in	1 case	At the end of	24	days	in	1 case
" "	10	"	"	1 "	" "	25	"		4 cases
" "	11	"		2 cases	" "	26	"		3 "
" "	12	"	"	4 "	" "	27	"		3 "
" "	13	"	"	3 "	" "	29	"		1 case
" "	14	"	"	2 "	" "	30	"		1 "
" "	15	"	"	5 "	" "	33	"		1 "
" "	16	"	"	5 "	" "	35	"		1 "
" "	17	"	"	2 "	" "	36	"		1 "
" "	18	"	"	4 "	" "	38	"		1 "
" "	19	"	"	2 "	" "	40	"		1 "
" "	20	"	"	6 "	" "	43	"		1 "
" "	21	"	"	4 "	" "	80	"		1 "
" "	22	"	"	5 "	" "	128	"		1 "
" "	23	"		1 case					—
									68 cases.

THE AFTER-TREATMENT OF THE DISEASE AND OF THE SURGICAL WOUND.

A great deal of the success to follow tracheotomy for croup will depend upon the after-treatment of the case. It was a want of recognition of the importance of this fact, that rendered success so infrequent previous to 1850 or thereabouts. Great stress has been laid upon this point by all recent writers on the subject. The most valuable work I have seen in this connection is from the pen of Dr. Sanné, of Paris,[3] based upon his year of service (1868) in the Hôpi-

[1] Edinb. Med. Journ., March, 1864.

[2] Op. cit., p. 33.

[3] Étude sur le croup après la trachéotomie, Paris, 1869.

tal Sainte-Eugénie, which afforded him many opportunities to operate, and to study the results of operations, and the subsequent course of the disease. During that year 102 cases of croup were received into the wards of M. Barthez, of which 83 were subjected to tracheotomy with a result of 18 recoveries. M. Barthez placed records of other cases at the service of the author, so that his volume is the result of an analysis of 662 cases of croup subjected to tracheotomy. Dr. Sanné has made good use of this material, and has discussed the subject of after-treatment, accidents, and complications with great detail and circumspection. Much that follows has been chiefly derived from his pages, which present partly much the same conclusions as are expressed by most authors; the similarity of argument, and often of language in many articles, indicating a common source, that of the great Parisian tracheotomists.

The operation being completed, and its immediate dangers over, the patient should be replaced in bed and be well covered up. His apartment should be kept at a comfortable heat (70° F. at least), the temperature being regulated by a thermometer. These precautions are necessary, because more or less well-marked chilliness almost always follows the operation, varying, usually, with the previous degree of dyspnœa and the amount of blood lost in the operation. The external opening should be covered by a bit of stiff gauze, to protect it from extraneous matters, as employed by Andree in the very first operation; best applied above the wound, straddled upon a strip of adhesive plaster. In addition to this, Trousseau[1] strongly recommended "covering the neck with a knitted comforter, or a large piece of muslin, so arranged as to compel the child to respire into its folds, and thus inspire air warm and impregnated with the warm vapor furnished by the expiration. In this manner several untoward circumstances are avoided: drying of the cavity of the canula and of the trachea, irritation of the mucous membrane, and the formation of coriaceous crusts, which, becoming detached in complete tubes or fragments of tubes, cause terrific fits of suffocation, and sometimes death by occlusion of the canula." Before Messrs. Trousseau and Paul Guersant had adopted this practice, they lost many of their patients by catarrhal pneumonia; but this accident had become rare since, and they thought it probable that the introduction into the bronchi of a warm and humid air was a very favorable circumstance.

The use of this woollen cravat renders less essential another practice much in vogue for the same purpose of warming and moisten-

[1] Arch. Gén. de méd., 1855, p. 265.

ing the inspired air; and that is keeping up an evolution of steam from boiling water, so that its vapor can be mingled with the inspiratory current, either by means of some special contrivance for conveying a current of warm vapor of water directly in front of the opening, or by allowing it to be generally diffused in the patient's vicinity. From personal experience of this practice in the medicinal treatment of croup, I would not feel disposed to forego it even with the use of the cravat. It appears to replace, in part, the moisture evaporated or absorbed from the exudative products in their transformation into the semi-solid or membranous form, and thus to keep them in a condition favoring their detachment and expulsion. Some operators keep the temperature of the room about 65° F., others, as Sayre, of New York, as high as 90°. That a high temperature is well borne in croup I have had ample evidence at a temperature of 80° to 85°, with an evolution of steam sufficient to cause the paper to loosen from the walls. Some of the German authors recommend keeping a sponge wrung out of hot water in front of the opening so that the air shall pass through its pores; a plan also recommended by Gerdy and Nélaton.[1]

If the patient does not react well from the chill, warm aromatic drinks should be freely given, and flying sinapisms be applied to various parts of the skin; the evidence being that under these influences the face gradually resumes its normal color, the pulse increases in force, and the respiration becomes quieter, so that the vesicular murmur can be heard in all portions of the lungs, except, perhaps, anteriorly, where intervesicular emphysema has taken place. At the end of a few minutes the child usually sinks into a calm, sweet sleep which lasts sometimes for several hours. In some instances indeed the child goes to sleep on the operating table, within a few minutes after the introduction of the tube.

With regard to details such as these, and others to be mentioned in connection with the dressings, Trousseau himself asserted that the older he became, the more convinced he remained of their importance.

The diphtheritic manifestations of croup are usually abandoned to themselves after tracheotomy. Trousseau's opinion was that the disease had exhausted all its action in the air-passages; and that if the patient could be prevented from dying by tracheotomy, recovery ensued in the natural manner.

Inasmuch as the diphtheritic manifestations frequently exist in the bronchi, endeavors are often made to aid in their destruction and removal, and to prevent their further deposition. Inhalations

[1] Bouchut, op. cit. p. 255.

of steam, sometimes charged with lime, volatile and other substances, are used to this end

Sanné endorses the opinion of Millard that the use of the cravat or comforter has rendered this practice more embarrassing than useful.

Dr. H. Trideau has suggested the utilization of the elimination of cubebs and copaiba by the respiratory mucous membrane.[1] He considers that the false membrane is susceptible of being attacked by remedies which are eliminated from the surface on which it has been deposited. Trousseau, Barthez, and Bergeron[2] have been favorably impressed with this view, and have employed these substances in numerous instances, and with varying results; some of them, however, highly satisfactory. Cubebs is preferred to copaiba on account of its not affecting the digestive organs; and the best form of administration has been found to be the oleo-resinous extract in doses of half a gramme to a gramme every two hours, in a mucilaginous emulsion. Bergeron prefers to give the extract of cubebs in the form of a saccharate. Its use is continued until no more false membranes are expelled, and the larynx seems free.

Isambert, André, and Millard recommend the administration of chlorate of potassa after tracheotomy.

Dr. Labat[3] recommends the use of acetate of potassa in large doses, ʒij in the twenty-four hours, administered in sweetened water. When expectoration is tardy and the tube becomes dry, he gives 10 grammes in 120 gr. of water; and at the end of two hours finds that the expectoration has become easy and abundant.

Barthez[4] at one time found great advantage from instillation into the trachea of a rather concentrated tepid solution of chlorate of soda.

The evacuations should be carefully watched. Diarrhœa and vomiting sometimes occur a few hours after tracheotomy has been performed, principally in children to whom emetics, particularly antimony, have been administered; and chiefly in those cases where, on account of the suspension of the function of absorption during the period of asphyxia, they have operated very little or not at all.

[1] Nouveau traitement de l'angine couenneuse, du croup, et des autres localisations de la diphthérie par le baume de copahu et le poivre cubèbe. Paris, 1866. Gaz. des hôp., 2, 1866.

[2] Gaz. hebd., 1869, 16, p. 253, 26, p. 44; Gaz. des hôp., March 5, 1870.

[3] Journ. de méd., Bordeaux, 1869: Bull. de thérap, 1869, 1, p. 190; Practitioner, June 1869, p. 377.

[4] Bull. gên. de thérap., May 30, 1858; Brit. and For. Med.-Chir. Rev., Jan. 1859; Amer. Journ. Med. Sci., April, 1859.

The resumption of normal function on the re-establishment of respiration, promotes the absorption of the contents of the intestinal canal; hence the catharsis and emesis. It is, therefore, unwise to continue the employment of this class of medicines long after they have ceased or failed to act; for even a spontaneous ejection of false membrane would be followed by similar consequences.

Traumatic fever sets in soon after the operation, at a period which may vary from a quarter of an hour to several hours, this variation being in accordance with the state of the patient at the time of the operation; the greater the depressing influences, such as dyspnœa and hemorrhage, have been, the later, other things being equal, will be the febrile reaction. This fever, in a favorable case, should subside in the course of one or two days, or coalesce into that attendant upon the diphtheritic affection itself. Its longer persistence is due to some impending complication. In some cases the violence of the reaction proves fatal within twenty-four hours; the slight extent of membrane, and the absence of evidence of other lesions on post-mortem examination, permitting no other conclusion.

The respirations, after subsidence of the fever, should not exceed forty in the minute, in a case progressing favorably, counted during sleep; though they will become more frequent under emotional influence, or cough. As the case progresses towards recovery the respirations gradually resume their normal frequence. Sometimes when respiration appears perfectly calm, and without effort, it will be found to be short and rapid. This is usually indicative of some pulmonary or other complication.

The circulation is proportionate to the respiration. During the febrile movement the pulse will vary between 120 and 140 beats in the minute; and it will subside as the patient progresses towards recovery. If it becomes much accelerated, say to 160–180 in the minute, the temperature of the skin rising at the same time, it is almost certain evidence of some impending complication. Bartels[1] states that with a pulse over 170, the patient is sure to be lost; that 152 a few hours after the operation makes the diagnosis unfavorable, while less than 130 is favorable; that a temperature of 39° C. (102° F.) is unfavorable, and a normal temperature the day after the operation is favorable; while sudden rise of temperature indicates complications or a relapse.

The expectoration at first contains more or less blood, according to the quantity which has passed down the trachea. In a short time it becomes mucous, thick, and opaque, sometimes forming large

[1] Loc. cit.

irregular masses. In other cases it remains transparent and more fluid, though still viscid. These are the characteristics of laudable expectoration. If the expectoration is purulent or serous, grayish, fetid, non-aerated; and trickles out instead of being coughed out, it is an unfavorable symptom. If the patient does not cough after tracheotomy, the prognosis is bad; for the mere drainage of fluids is insufficient to prevent gradual asphyxia. The removal of false membranes is probably attended with more or less excoriation of the mucous membrane from loss of epithelium, and it is in part to the reparative processes here that the discharges occur, which, on desiccation, form the coriaceous crusts that so often appear shortly after the operation. The inspiration of warm and moistened air tends to retard this desiccation and facilitate the removal of the discharges by cough. Should these matters accumulate in threatening quantity, it would be good practice, as recommended by Prof. Heuter,[1] to endeavor to remove them by aspiration, a method more certain and powerful than the action of medicinal expectorants.

Some authors contend that the false membranes are eventually lifted from their seat by serous exudation; others contend that they are loosened by suppuration beneath them.[2] In the latter case the presence of large quantities of pus in the expectoration would be readily accounted for.

The nutrition of the tracheotomized patient is a point of the highest importance. The appetite is usually satisfactory for the first two or three days; after which it often diminishes, sometimes to such a degree that the patient refuses nourishment. Complications of all kinds tend to diminish the appetite. Every effort should be made to sustain the child. From the very first day, in the French hospitals, thin soups are given, and red wine or vinous lemonade as a common drink. The following day soup and milk are given; and one or two fresh eggs are soon added to the diet. The use of solid food is approached as rapidly as possible, ordinary diet being allowed, and care taken to make it as nutritious as possible. From the second day a little generous wine (de Bagnols, at Sainte-Eugénie) is given diluted with a little water.

In some cases fear, caprice, dread of the accidents attendant on deglutition when diphtheritic paralysis is appearing, cause difficulty of feeding. In some cases it is simple repugnance; in others a resistance sufficient to inspire grave disquiet. A great deal of care, tact, and humoring is necessary under these circumstances to induce the patient to take food. Delicacies and confectionery may be

[1] Op. cit., p. 62.

[2] Flint's Practice, 1868, p. 259.

allowed, rather than to permit the patient to remain without eating. An artifice will sometimes convince the child that it can eat. The return of appetite is almost a certain promise of recovery. (Sanné.) Sometimes liquid nourishment alone is taken. If paralysis ensue, liquids cannot be taken as well as semi-solid food. To assist nourishment and rouse appetite, cinchona is often given, in the form of wine or extract suspended in mucilage, or in an infusion of sweetened coffee. When the patient cannot swallow, or does not take food in sufficient quantity, we must resort to artificial nourishment by the stomach or by the rectum.

Trousseau, and others after him, recommend the use of the stomach tube for conveying nourishment in cases of inability or unwillingness to swallow. A small tube passed through the nostril and guided along the posterior wall of the pharynx until two or more inches had passed down the œsophagus, would probably be preferable to one passed through the mouth, as it would avoid the epiglottis; while it would easily permit the passage of milk and other thin liquid nourishment.

Diphtheritic Paralysis.—Sanné states that diphtheritic paralysis at the end of a variable period attends nearly all the cases operated upon for croup; and he considers this complication sufficiently habitual to entitle it almost to be considered among the phenomena of normal evolution; belonging essentially to the diphtheritic affection itself, however, and not to tracheotomy. It occasionally necessitates the retention of the canula when other croupous or diphtheritic phenomena have ceased. In this condition milk and other fluids will not be thoroughly swallowed, but will pass down the larynx and trachea, exciting cough, or they will trickle through the wound without reaching the trachea. These phenomena will also occur from other impediments to deglutition independent of diphtheritic paralysis.

Mr. Spence[1] is of the opinion that the passage of aliment by the tube is peculiar to diphtheria; for in a very large experience of tracheotomy performed for different kinds of disease or accident, he has never seen the fluid food ejected by the tube, except in that disease; and he asks, "Is it not probable that the same paralyzed state of the glottis may allow portions of fluid nutriment to pass into the air-passages in other cases of diphtheria in which tracheotomy had not been performed?"

The care of the canula is a consideration of the gravest moment.

[1] Tracheotomy in Diphtheritic Croup. Edinb. Med. Journ., March, 1864, p. 782.

The tube is apt to become obstructed by retention of expectorated products, whether mucous, purulent, sanguineous, or membranous; and, if not freed from them, the patient will become suffocated. Cases of death from this cause are by no means infrequent. It is, therefore, of the greatest importance that a competent attendant, by preference a medical man of some judgment, and familiar with the nature of the accidents which follow tracheotomy and the use of a tube, be at the side of the patient, or, at least, within immediate call, until all danger from this source has passed. Relief must be immediate, in case the artificial passage becomes occluded. Obstruction in the tube will be indicated by peculiar moist sounds in respiration, or by the restlessness of the patient. The inner tube should then be removed and cleansed, and the outer tube be swabbed out with a soft mop or a feather, after which, if the passage is clear, the inner tube may be replaced. The removal and replacement of the inner tube, and the cleansing of the outer tube usually excite effectual cough with more or less discharge. Partial or complete occlusion of the artificial opening by the finger during the explosive movement of cough will render it more effective. A soft sponge, mop, or cloth should be at hand to catch any secretions or discharges that present at the external extremity of the canula, and prevent them from being drawn back by the current of inspiration. A shred of false membrane presenting at the extremity of the tube produces a characteristic flapping, sometimes accompanied by harsh and stridulous sounds; cough is excited by the impediment to respiration, and after more or less effort the membrane is usually driven through the canula. If this does not take place promptly, the inner tube should be removed, and if the membrane is not driven through the outer tube, an attempt should be made to catch it with curved forceps. Should this be unsuccessful, cough should be excited by passing a feather or delicate mop through the tube into the trachea. If this fail, a little warm water should be dropped *guttatim* into the tube, and be repeated every ten or fifteen minutes; or an elastic catheter be introduced and aspiration made. It is an important matter to excite cough. If the obstructions continue in spite of all these measures, the entire canula should be removed, but, on account of the difficulty of reintroduction, this should not be done, the first day at least, by an unskilled hand. Very often the mere reintroduction of the canula will excite effectual cough. Where the canula is not well borne, when it cannot be replaced, or when it prevents expulsion of matters from the trachea, some other means must be employed to maintain the potency of the artificial respiration. Care must be taken to recognize a necessity for these and similar mani-

pulations, so that the parts be not irritated unnecessarily, or sleep disturbed without cause. The character of the respiration will afford the proper indication for interference. The condition of the inner canula should be observed every two or three hours, to make sure that viscid secretions have not adhered in serious quantity upon its surface; and whenever it is removed, the nature of its contents should be carefully examined in water, so as to assist the judgment as to the progress of the case.

Changing the Tube.—At the end of twenty-four hours or thereabouts the tube should be changed, a clean one being inserted to replace the tube introduced at the operation, and now soiled with blood and sputa; as well as to permit an early inspection and dressing of the wound, an important point in many instances, in view of impending diphtheritic deposit, gangrene, erysipelas, etc. It is best to make the first change by good daylight, and the usual time stated may be anticipated or postponed a few hours accordingly. Trousseau and many others do not approve of the early dressing, but it is recomended by Barthez, Millard, Sanné, and others. The inflammation excited by the presence of the tube is sufficient, in the course of twenty-four hours, to pour out enough plastic lymph to give the tissues a certain amount of resistance, and the sides of the opening in the soft parts are sufficiently firm, except in very rare instances, to permit the safe passage of the tube; though not as firm as they become subsequently.

At the first withdrawal of the tube it is desirable to have efficient assistants at hand to control the movements of the child, who should be placed with the neck in a good light, and somewhat in the position for tracheotomy itself. The removal is immediately followed by cough, with the discharge of sputa, blood, false membrane, or whatever products may be in the trachea. If everything is going on well, the tube, supposing it is of silver, though soiled by mucus, blood, or pus, will be otherwise perfectly white; if blackened, it denotes some unfavorable complication. The wound should be carefully cleaned with soft sponge, charpie, or cotton, moistened with warm water. If healthy, the parts will be normal in color, pliable, and the edges everted. In some instances the parts will be so soft that they will turn inwards and close the wound. It is then necessary to insert the dilator and keep the wound open until the fresh tube has been inserted; and it is here, I think, that the dilator of Trousseau, or one of its substitutes, is most serviceable, much more indispensable than in the first introduction of the tube. It permits great freedom of respiration, and, exciting cough, gives greater exit to accumulations in the air passages, or permits the use of the forceps for the extraction of false membrane. The state of the larynx

should be examined before the tube is replaced. If permeable to air, and no contraindications exist, there may be no further necessity for the tube. Several cases of this kind are on record. If the difficulty of respiration has been due to paralysis of the dilators of the glottis, rather than to false membrane, or inflammatory swelling which has subsided, it will not be safe to close the wound even though the patient breathe readily by the natural passages when the artificial opening is occluded by the finger; for if the disease be not receding, the paralytic condition may recur and necessitate a second operation.

If the canula is replaced, the external parts should be first covered with a layer of olive oil, cold cream, or collodion. Dr. Sanné speaks very highly of collodion as a preferable application; it secures the skin from contact with the fluids of the wound, and diminishes the inflammatory tumefaction. Each morning the layer of collodion is found in part detached, and can be readily removed to give place to a fresh application. If adherent in places, the denuded parts only are covered. In most cases the skin beneath is healthy; in some rare cases there is a slight miliary eruption.

The canula is then changed once every day, the state of the larynx being examined, and the wound dressed. When air begins to pass through the larynx, the tube may be left out for a few moments each day, but should be replaced on the appearance of any difficulty of respiration. Such difficulty may arise from incomplete permeability of the larynx, and contraction of the wound; or occlusion by inward pressure of soft exuberant granulations; the lodgment of false membranes in the wound or in the larynx; spasm of the larynx; fear of dyspnœa, etc. If the granulations block the passage, it would be well in many cases to insert a blunt catheter and slide the tube down over it, rather than to force the tube through this vascular tissue and run the risk of hemorrhage. From day to day this period of withdrawal of the tube may be lengthened until it is left out all the time. One of the most favorable indications is the passage of sub-glottic sputa by the mouth. When the tube has been definitely withdrawn, the wound usually closes spontaneously; cicatrization being completed within a few days. If the cicatrization does not take place promptly, and there be no disease of the wound itself to retard it, it may be taken as evidence of some approaching complication,—pneumonia, bronchitis, paralysis, eruptive fever.

There is no necessity for any dressing to hasten cicatrization in a normal wound. If covered with an impermeable dressing, asphyxia may ensue as the result of some sudden impediment to respiration, whether spasmodic from emotion or from access of cold air, or from

retention of sputa in the larynx; and death may follow in the absence of an attendant capable of rendering the proper service. In consequence of several accidents of this kind, M. Barthez abandoned this system, and simply covered the wound with a light compress to prevent irritation from the clothing. By this plan there is no danger from retention of sputa in the larynx; one opening supplementing the other in case of necessity; while by the time the wound has closed, the larynx has become accustomed to a resumption of its functions.

If there is delay in cicatrization, it may be hastened by astringent or stimulating applications. Nitrate of silver is used most frequently for this purpose. Exuberant granulations are repressed in like manner; or, if too large for cauterization, are snipped off, and then their stumps are cauterized.

The canula can usually be dispensed with in from five to nine days.

The Casualties which Prevent Recovery.

Inasmuch as this paper is limited to the subject of croup in its relations to tracheotomy, the casualties which are incident to the disease, independently of the operation, will not be discussed. These are: extension of the exudation, general systemic infection, diphtheritic paralysis, albuminuria, pneumonia, and fibrinous deposits in the cardiac cavities.

In considering the casualties attendant on the operation, Sanné's volume is here closely followed. Complicating lesions are very frequent, though manifested in greater proportion at different seasons. We extract from Sanné[1] the following table of frequency of complications attending the successful cases of tracheotomy in the Sainte-Eugénie Hospital for the years indicated.

Year.	No. of successes.	No. in which there were complications.
1855	2	1
1856	3	1
1858	11	1
1859	20	3
1860	7	1
1861	7	2
1862	19	14
1863	18	10
1865	27	22
1866	22	12
1867	10	5
1868	17	12
	163	84

[1] Op. cit., p. 48.

Hemorrhage after the operation is most frequent in the hours immediately following, being often a continuance of hemorrhage attending the operation. In some instances it occurs when the outer tube is removed for the first time; and sometimes it recurs for days in succession at each withdrawal of the tube; and this even in cases unattended with much hemorrhage at the operation. In other cases it occurs for the first time several days after the operation. Cases of this kind are cited by André,[1] Bœckel,[2] Sanné,[3] and others. André mentions a case in which secondary hemorrhage occurred on the 4th, and again on the 7th day. In Sanné's cases the hemorrhage occurred in one case on the 1st day and continued to recur until the 11th, in one on the 4th day, in one on the 5th day, in two on the 6th day, and in another on the 7th day.

When a moderate hemorrhage occurs during the operation, it is usually arrested almost immediately upon the introduction of the tube. This is by no means always the case. The compression exercised by the tube upon the divided tissues and the divided vessels is insufficient if a vessel of some size has been divided, and the hemorrhage may persist to an alarming extent. In some cases the blood escapes at the inferior angle of the wound or by the tube, and suitable means can be employed to stanch it. In other cases the blood may flow externally and internally at the same time. It then provokes cough, by which some of it is discharged through the canula; but, at the same time, the act of coughing keeps up the hemorrhage. Usually the cough soon becomes quieted, and the bleeding is arrested; but sometimes it may continue to such an extent as to eventuate in ultimate death by anæmia or by asphyxia. The mere presence alone of blood in the tube may occasion asphyxia.

Three personal observations recounted by Sanné give an idea of the dangers incurred by such an accident.

1st Case. He had occasion to perform tracheotomy on an infant in the wards of M. Bergeron. Everything had gone well during the operation, the hemorrhage having been very moderate; some cough had taken place and blood had escaped through the canula, but the patient had rallied. While sitting up well covered, about to be removed to bed, he made violent efforts of inspiration, became cyanosed, and fell upon the table. Sanné attempted to remove the inner tube, thinking it was blocked up, but found that the sanguineous flow, which had persisted after the operation, had covered the plate with a viscous mass which had agglutinated the surfaces of the different pieces of the canula. He immediately removed the entire concern, but

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[1] Du traitement des cas de croup observes à l'hôpital des Enfants en 1856, p. 38.

[2] De la trachéotomie dans le croup, Strasburg, 1867, p. 45. [3] Op. cit.

although the whole scene occupied less time than it has taken to narrate it, respiration had ceased. He introduced the dilator into the wound, and practised artificial respiration while an assistant flapped the face vigorously with a wet towel. Finally, at the end of several seconds an inspiration took place; others followed, at first at rare intervals, then more frequently, and finally regularly. A second canula was introduced; the patient rallied, and was put to bed. The first canula was found completely occluded by a plug of clotted blood and fibrin which had been forced into the tube by the efforts of cough. This case, he adds, shows with what care the minutest details should be observed after the operation.

If blood flows from the canula, the tube should be frequently cleansed both internally and externally.

2d Case. An infant, 3 years of age, had been tracheotomized in the third stage of croup. The operation was a long one, and was attended by a hemorrhage which persisted after the introduction of the canula, and resisted all measures for its arrest. Blood flowed into the trachea and provoked a violent cough which projected it through the canula to the floor of the apartment. From time to time a click was heard behind the canula, indicating the presence of false membrane. Some débris of false membranes were removed by forceps introduced through the tube, but the hemorrhage was not arrested; the child sank rapidly, became cold, the integuments paled, the pulse diminished. The canula was withdrawn and a dilator introduced into the wound to favor the expulsion of the membranes. Some fragments were rejected; but the hemorrhage continued, and the patient succumbed in spite of all that could be done.

In the 3d case (obs. 6 in detail) recovery ensued, notwithstanding accidents of extreme gravity; in spite of abundant hemorrhage which persisted continuously more than five hours, and which brought the patient several times to the verge of death. The first canula was replaced by a larger one, but this proved insufficient, though effectual at the first. Compression of the wound with agaric was of no greater service. The patient really owed his life to the employment of large doses of alcohol (about 80 grammes of rum), under the influence of which the blood was arrested almost instantaneously.

The hemorrhages which appear at a later period are habitually less abundant and less grave. They are not always recurrences of losses which have already complicated the operation. Sanné collected 19 observations of secondary hemorrhage; in eight of them the operation had not been bloody, in three others the detail as to hemorrhage is not given. In one case (obs. 7) the loss of blood continued from the first time of changing the tube until the 11th day. The patient could not be disembarrassed of his canula without the blood spurting in a jet; in the intervals between the dressings a slight discharge from the canula was sometimes observed. This case recovered. Of the whole 19, death occurred in 11, either directly from the hemorrhage, or by the anæmic state it brought on.

The expectoration will continue tinged with blood for twenty-four

or thirty-six hours after the cessation of the hemorrhage. If the loss of blood has been slight, it is not to be regarded as a matter of great moment, but if it has been at all copious, it may produce sufficient anæmia to prevent recovery.

On the other hand, though the dyspnœa may cease, in great measure, in a comparatively short time, death may occur from pulmonary inflammation excited by the blood which has remained for some time in contact with the ulterior divisions of the bronchi.

The causes of hemorrhage are:[1]—

1. Division of a vessel during the operation. If the operation is rapidly executed, the loss of blood is insignificant and may usually be arrested by the compression of the canula when introduced, the occlusion of the end of the vessel being permanent as a rule; but in some instances the vessel is ruptured when the canula is removed, and bleeds again; and this accident may occur several days in succession.

2. The necessary manipulations of the dressing, either in extracting eschars or false membrane; or a vessel momentarily occluded may be ruptured by the reintroduction of the canula.

3. The pressure exercised by the canula may ulcerate the walls of vessels not divided in the operation.

4. The condition of the blood itself in diphtheritic cases may be a predisposing cause to excite hemorrhage by the accidents already mentioned.

To this list I would add another cause, and that is the vascularity of the delicate granulations that are formed in the track of the wound.

Treatment.—Hemorrhage may be repressed, if slight, by the application of small pieces of cotton, one laid upon another as they become saturated, in succession. The magma thus formed exercises a gentle compression. It is well, if the hemorrhage is severe, to premise these applications by compression with the finger at the lower angle of the wound to diminish the flow, but this is too fatiguing to the patient to be continued for any length of time. If these efforts do not suffice, a plug of charpie saturated with perchloride of iron may be used; but this is very painful, and it may become a point of departure for an inflammation of the wound. The local contact of bits of ice inclosed in a cloth should be of service.

Sanné states that the advice to remove the canula and search for the bleeding vessel should not be followed; because it abandons

[1] Sanné, op. cit., p. 54.

the only compressing agent which can be of any service, for a search often fruitless, at any rate very protracted, and during which the patient may die of the hemorrhage.

Should the canula be removed, however, the bottom of the wound may be painted over with a brush dipped in perchloride of iron; though on account of the inconveniences of this agent, it should not be employed except as a dernier resort.

Sanné recommends very strongly the internal administration of alcohol in large quantities; by means of which he has seen hemorrhage arrested several times when all ordinary means failed. He says we need not fear to give too much alcohol; large doses are the most certain, and the patient may be allowed to drink as much as he will take.

When the hemorrhage has moderated, the patient should sit on the bed supported upon the bolsters, so as to avoid the penetration of the liquid into the bronchi. If syncope seems imminent, he is to be laid down, and sinapisms are to be applied to the surface, and at the same time the face is to be slapped with a wet towel. Syncope is to be prevented at all hazards, although under other circumstances it is considered favorable for the arrest of hemorrhage.

Inflammation of the Wound.—The mechanical injury done to the soft tissues during the operation, to the peri-tracheal connective tissue in the introduction of the canula, the exposure of the surfaces of the wound to sputa, pus, false membranes, and alimentary matters which pass by the sides of the tube, and the constant presence of the foreign body, produce more or less inflammation of the wound in nearly every instance. Sometimes this inflammation exceeds what is necessary for cicatrization, and it becomes phlegmonous. The inflammation takes place about the end of the first twenty-four or thirty-six hours. The tumefaction may be of such extent as not only to require loosening of the cords which confine the canula, but it may so deepen the wound as to render the canula too short, and thus expose the patient to emphysema and its suffocative accidents. The skin may fail to cover the subcutaneous tissues completely, and these exposed structures may become affected with erysipelas or with diphtheritic exudation.

The skin becomes tense, firm, and immovable, and inflamed for a considerable extent around the edges of the wound. It is frequently covered with little miliary vesicles filled with a white opaline fluid; sometimes very few in number, often very numerous; sometimes situated above the wound, but more frequently below it. It is not rare to see them form a sort of crescent following the contour of

the protecting layer of gum or oiled silk, over all the surface exposed to the contact of the fluids discharged through the tube.

When the inflammation is simple, the vesicles dry up and the epidermis reforms beneath them. In contrary cases they terminate in ulcerations, the bottoms of which very often exhibit a tendency to become covered with diphtheritic exudation.

Simple inflammation rarely terminates in suppuration; but often in ulceration, the lesion being usually limited to the angles and borders of the wound, especially in its inferior portion. Sometimes it implicates the parts around, and may produce extensive loss of substance; but this is infrequent. The ulcerated surfaces usually present a rose-colored bottom, rarely a gray one, and the edges are regular and not much elevated. The metallic lustre of the tube is not altered by the discharges.

If recovery is to take place, these disorders, after having persisted for several days, subside; the redness fades, the induration is resolved, the ulcerated portions close, the wound becomes smaller, and resumes its progress towards cicatrization, which had been completely arrested during the period of phlegmasia.

The inflammatory complication is never very grave by itself; it is almost inevitable, and is perfectly cured when no accident of another nature is produced.

Treatment.—In moderate inflammation it suffices to cleanse the parts frequently and cover and recover them with some mild unguent, as sweet oil or cold cream. If there is slight tumefaction, applications of collodion are of great service. If more extensive, the same means are employed, and the canula is removed from time to time for as long a period as possible, so as to get rid of the main factor of irritation. The induration of the edges of the wound makes a tolerably rigid tract, so that the patient can readily get enough air. While the canula is out the patient must be carefully watched, for he supports the deprivation with great difficulty the first few days; respiration becomes impeded; suffocation may rapidly ensue; and the canula has to be replaced at the end of half an hour, fifteen minutes, or even earlier. If there is much tumefaction of the connective tissues, a longer canula is substituted to prevent its being forced out of the wound and thus producing serious accidents. Ulcerative tendencies are combated locally by a solution of carbolic acid, and in case of need, by the nitrate of silver.

Erysipelas is not a frequent complication. It may occur independently of the vicinity of erysipelatous patients. The only premonitory signs are diminution of appetite and augmentation of fever; the pulse becoming more frequent, the temperature increas-

ing, and the skin becoming dry. Vomiting does not occur; nor even chill, unless it passes off unperceived. It is sometimes attended with considerable and extended tumefaction. It may be confined to the vicinity of the wound, or it may take the serpiginous form and run over the whole body. The prognosis is grave, as most of the cases in which erysipelas occurs die, even though it may be of moderate extent. Sanné relates, in detail,[1] one exceptional case in which recovery took place, although erysipelas had spread over all the surface of the body.

Treatment.—The treatment requires the local use of bland and unirritating unguents. Sanné thinks very highly of the use of collodion,—renewed daily, or several times a day,—which modifies the local inflammation, and rapidly diminishes the redness and tumefaction. If the canula can be dispensed with, it is well to remove it, as a considerable source of irritation is thus gotten rid of. The general treatment requires the use of tonics. Emetics and cathartics can exert only an unfavorable influence.

Gangrene.—Gangrene is, perhaps, the most frequent complication. Even cases of recovery are not exempt from it.

Sanné recognizes two species of gangrene:—

1. Superficial gangrene of the internal surface of the wound; frequent, benign, almost always the result of compression of the inflamed tissue by the canula.

2. Extensive and deep gangrene of the tract of the wound, with or without extension to the skin, enlarging the opening and tract of the wound, and caused both by compression and diphtheritic infection; a form graver and more rare.

Superficial gangrene usually appears about the third or fourth day after the operation. Although the general evidences of the condition may not be recognizable at this early date, there is one sign which Sanné says has never deceived him, and that is blackening of the canula; it being understood that a silver canula has been employed. The extent of the discoloration is an indication of the extent of the gangrenous process. It rarely reaches the posterior third of the tube unless there is an ulceration of the trachea at the same time. If the gangrene is extensive it entails considerable loss of substance. The wound becomes filled with fragments of eschars, shreds of cellular tissue or muscular tissue, sometimes cartilaginous débris from the tracheal rings; the whole enveloped in a serous, brown, and fetid pus. If the patient survives, these eschars are discharged, and suppuration becomes normal; but the wound is en-

[1] Op. cit., obs. x. p. 205.

larged and its walls irregular, perhaps penetrated by sinuses; the denuded surfaces being covered with a layer of healthy granulations. The deformity of the cicatrix will be proportionate to the loss of substance. The general condition of system is usually proportionately affected, and when amendment takes place the gangrene is arrested. The absence of gangrene, Sanné affirms, is an almost infallible pledge of recovery.

Treatment.—Sanné does not think that gangrene can be prevented. He counsels removal of the tube for as long a time as possible whenever an inflamed condition of the parts and tumefaction of the tissues indicate undue pressure. Applications, such as cold cream, sweet oil, and glycerole of starch, should be applied upon the skin. If this is insufficient, and the blackening of the canula announces mortification of the tissues, it will be well to cauterize the wound freely with nitrate of silver. If the mortification continues, the wound will become covered with an extensive brown eschar: cauterization is then no longer of value, nor any other topical measures either. The only resource left is to keep the tube out of the wound as long as possible, and to sustain the system by the use of tonics. When the eschar becomes detached, the wound should be bathed frequently to free it from fetid pus and débris of mortified tissue; and after each cleansing it should be touched with a solution of carbolic acid, one part to one hundred. This destroys the putrid products at the surface of the wound, and excites the vitality of the tissues, thus accelerating the discharge of the eschars, and preventing systemic infection by absorption of these products.

Alimentation, quinine, and generous wines are indispensable complements of the treatment.

Diphtheria of the Wound.—Sanné states that false membrane is not apt to appear upon the surfaces of a deep wound, but is rather manifested upon the superficies where the skin has been incised, and thence extends to the surrounding parts. He insists upon it, that eschars of the wound are often confounded with plastic exudation. Diphtheria of the wound appears from the second to the fourth day after the operation. It is part of the anatomical characteristics of the disease, and is, of itself, to be considered as a matter of gravity only when persistent or frequently reproduced; being, in fact, an evidence of the intensity and tenacity of the general affection.

Treatment.—Cleanliness, frequent and lengthened removal of the tube, are here the principal elements of treatment, the same as for all other complications concerning the wound. Sanné does not favor the use of topical agents to destroy the membrane, as most other writers do, unless it is of such great extent as to threaten

serious accidents by its mere presence. He prefers the use of alum or tannin in powder with equal quantities of starch, or tannin with glycerole of starch, which is of excellent service in superficial exudation. For the walls of the wound itself he has found the application of lemon-juice of benefit.

Emphysema is not a very frequent complication. Sometimes it begins during the operation; more frequently, it comes on during the first few hours after; sometimes not until the next day. Of 662 observations studied by Sanné, he could collect only eighteen instances, six of which had occurred during the same year, while in many other years there had been no cases. Millard cites four cases.

Emphysema, in the great majority of instances, is the result of faulty operations; the most frequent cause being denudation of the trachea during ineffectual efforts to introduce the tube. If the tube remains for several instants in a false route, the air is forced both by inspiration and expiration, into the lax cellular tissue, and emphysema soon commences. In such cases, it is not rare to find at the autopsy, an abscess of the mediastinum in addition to the emphysema.[1]

An incorrect incision of the trachea is a no less powerful cause of emphysema. The vicious incision may be lateral; it may be double; it may be too long; it may be too short; it may be too low down.

The incision in the trachea may not be in the same line as the incision through the integuments, but be to one side. If the tube is promptly and securely introduced under such circumstances, emphysema will not occur; but if, as is usually the case, several ineffectual attempts precede its introduction, some denuding of the trachea inevitably takes place, and rapid emphysema is the consequence.

The trachea may be perforated through and through, the second or accidental incision being posterior or else lateral. Sometimes the tube may be pushed through this second incision into the tissue surrounding the trachea, and thus produce emphysema; but this additional form of the accident is rare.

More frequently the tube is placed in the cavity of the trachea; but a certain amount of air escapes through the second incision, and thus produces emphysema. Emphysema is much more certain to result in this way than the other, for if the tube passes through the second opening, only a small quantity of air can pass

[1] Sanné details several cases of this kind. Kühn, op. cit., p. 149, cites one from Barthez.

through it; but when the tube is in the trachea, the air passes readily, and easily issues in part by the fissure left by the bistoury.

If the incision is too long, the tube is soon forced out of the trachea into the connective tissue, or it may rest on the inferior angle of the tracheal wound, so that the inspiratory current is divided into two routes, in either instance producing emphysema.

If the incision is too short, or a mere puncture, there will be emphysema into the connective tissue during the time lost in finding the incision and enlarging it.

If the incision is too low down, the tube may not be long enough to reach the cavity of the trachea, which is here at a greater distance from the external surface, and thus emphysema will take place while another tube is being procured.

The tube should be long enough to reach into the trachea; too short a tube is an inevitable source of emphysema.

Tumefaction of the tissues may force a tube out of the trachea and thus produce emphysema. Emphysema itself may give rise to additional emphysema in the same manner.

Improper fastening of the hands which confine the tube may render it liable to be forced out by cough, and thus produce emphysema.

If the bevel of the extremity of the tube is too long, a portion of the orifice may rise above the lower edge of the wound, and thus occasion emphysema.

Another cause is insufflation through the tube to resuscitate a patient apparently dead; the efforts at which may be too energetic, and thus rupture some of the pulmonary vesicles.

Sanné reports a case of this kind in detail[1] in which insufflation ruptured the pulmonary vesicles and forced the air into the mediastinum, thence into the tissues of the neck, whence it reached the face, and the chest as far as the level of the nipple. The patient died the next day.

If the tube or catheter used for insufflation is not placed within the trachea, the cellular tissue will be blown up.

Emphysema is sometimes limited to the vicinity of the wound; sometimes it reaches the angle of the jaw; it rarely extends upon the face, but it may descend over the neck and chest reaching the shoulders, the arms, and the back. I have seen it extend from the zygomatic process of the temporal bone down over the chest, as far as the second or third rib. In some instances it will become general. If limited to the vicinity of the wound, and of moderate extent, it is of little consequence. If extensive it may produce

[1] Op. cit., obs. xv., p. 222.

dyspnœa; and even force the tube out of the trachea, necessitating the substitution of a longer tube. Its duration depends on its extent and its cause. It sometimes disappears in the course of a day or two, and sometimes lasts a week or more.

Treatment.—If due to too short a tube, a longer one should be employed. If this is not at hand, a catheter may be substituted until a suitable tube can be obtained, the edges of the tracheal wound being kept separated meanwhile by the dilator, forceps, or blunt hooks of lead wire, hair-pins, or any other extemporaneous temporary contrivance. Gentle frictions will sometimes succeed in forcing out a good deal of the air.

Dr. Watson relates a case in which death occurred in a child 10 months of age, 38 hours after the operation, in which there was found an "emphysematous distension of the anterior mediastinum, by which the head was partially displaced towards the left side. This appeared to have resulted from the air finding a more ready access to the expanding thorax through the wound, and external to the trachea, than through the obstructed bronchi." (*Ed. Med. Journ.*, Jan. 1861).—*Am. Journ. Med. Sci.*, April 1861, p. 577.

Abscess of the Mediastinum.—An abscess of the mediastinum has sometimes been found in post-mortem examinations of patients who have undergone tracheotomy for croup. Millard was the first to call attention to this complication; since which a number of cases have been recorded by others. Sanné, in his essay,[1] states that he has been able to collect ten cases which had been observed in the service of M. Barthez. Créquy, Pelletier, Roger, and Bœckel have also reported cases. It is likely, too, that some cases have existed in which the opportunity of verification by post-mortem was not allowed. The lesion, however, is rare.

Sanné attributes this complication to the operator rather than to the operation. In all the observations which he had encountered, the causes had been of the same nature as those which occasion emphysema. All mechanical injury to the trachea by improper incisions, and in effectual attempts to introduce the canula, favor phlegmonous inflammation of the wound, which, once set up, rapidly reaches the connective tissue of the mediastinum. He remarks that all lesions of the wound when unaccompanied with denudation of the trachea, remain limited to the wound and do not invade the mediastinum. He instances one case[2] in which it appeared to have been produced by too deep a use of the actua cautery in an attempt to arrest deep gangrene of the wound, the patient dying on the following day; and answers an

[1] Op. cit., p. 107. [2] Op. cit., obs. xix., p. 230.

objection which might be made as to the shortness of the interval in producing such a result, by mentioning another case in which the patient died the day after the operation, and in which, at the autopsy, a purulent infiltration was found lodged in front of the trachea and descending two or three centimetres beneath the sternum.

The pus is sometimes collected in an abscess the size of an egg; sometimes it extends from the wound in the integuments more or less deeply in the mediastinum; and sometimes exists as a simple infiltration in this locality. It has been found on all sides of the trachea, and also enveloping the œsophagus. In all the cases the wound of the integuments was the point of departure. In two cases the sternum was denuded and necrosis had commenced. Emphysema of the mediastinum, of the adjacent subcutaneous tissues, and of the lungs frequently coexists with the abscess.

The symptoms are obscure. General diphtheria, pneumonia, or broncho-pneumonia usually exist at the same time, and their symptoms mask those of the abscess. In cases in which there were no such complications, intense fever with dyspnœa and agitation suddenly supervened at a period when the patient appeared doing well.

Treatment.—Sanné says if the abscess could be diagnosed, the only rational treatment would be to trephine the sternum; but who, he asks, would dare adopt such a procedure upon an infant who had been tracheotomized for croup?

Ulceration of the Trachea.—M. Roger in 1859 published an article,[1] based on an analysis of 21 cases of ulceration of the trachea produced by the presence of the canula after tracheotomy. Dr. Sanné details the result of his own study of 17 cases, all of which occurred in the service of Barthez.

The lesion may be superficial and consist simply of destruction of the epithelium; but more frequently the mucous membrane is destroyed; and the cartilages are exposed whether healthy or diseased. In some cases the cartilages are completely destroyed and the tracheal wall is separated from the surrounding connective tissue by its fibrous layer only This, too, may give way, and the interior of the trachea may communicate with the exterior by one or more new apertures.

In the greater number of instances, the ulceration exists upon

[1] Des ulcérations de la trachée artère produites par le séjour de la canule après la trachéotomie, Arch. gén. de méd., ii., 1859; Bull. de l'Acad. de méd., March, 1859; Bull. de thérap., 1859, p. 443; Actes de la Société des hôp., Paris, 1861, p. 57.

the anterior wall below the inferior angle of the tracheal wound, at a point corresponding with the inferior extremity of the canula, the surface between the ulceration and the tracheal wound being healthy in most instances. In some cases the alteration commences at the inferior angle, extending in length or breadth to a greater or lesser degree. In one of Sanné's cases the lower angle had been destroyed and the wound was lengthened to the extent of one centimetre. In another case the borders of the tracheal wound were irregular and torn; the rings were thinned, and on their surface were fragments of cartilage in course of elimination; this lesion being accompanied, below the wound, by an ulceration, which had denuded and diseased the cartilages. The posterior wall was also interested. M. Roger had seen two cases of ulceration confined to the posterior wall, and four in which both walls were ulcerated. In one of these cases the trachea was perforated posteriorly. Dr. Sanné had never seen a case of this kind, but had seen several in which the ulceration had made the circuit of the trachea; and two in which the lateral walls were implicated. Roger cites four cases of perforation; Sanné three, in one of which three perforations existed, placing the tracheal cavity in communication with the inferior portion of the wound in the integuments; and in another were two large perforations the floors of which were formed by the brachio-cephalic trunk.

Holmes,[1] in discussing the subject of the ulceration of the trachea, refers to an instance in which the innominate artery had been opened by ulceration.[2]

Schneevogt[3] saw a tracheotomized child die on the ninth day, from hemorrhage due to erosion of the innominate artery.

The ulceration may be extensive without producing perforation. In four cases Sanné saw the mucous membrane and cartilage destroyed, nothing remaining but a fibrous or cellular layer sometimes very thin and transparent; and, whatever the extent of the ulceration, the thinnest portion of the tracheal wall was almost always at a point corresponding to the lower extremity of the canula. Thus, in one of the four cases cited, a very thin cellular layer was all that separated the end of the canula from the brachio-cephalic trunk at its point of bifurcation.

There do not appear to be any truly characteristic signs of the existence of this lesion; though many circumstances are mentioned by Barthez, Roger, Sanné, and others. Its possibility must be

[1] Op. cit., p. 326.

[2] Path. Soc. Trans., xi. 20.

[3] Kühn, op. cit., p. 146.

borne in mind, in case of the appearance of any symptoms which might be the probable result of such a lesion.

The occurrence of the accident should be avoided as far as possible by the selection of canulas of proper shape and curvature, and freely suspended on the supporting plate. If ulceration be suspected, the canula should be removed. If it is impossible to dispense with a tube, one of Durham's canulas should be employed which is so constructed that its two extremities are on rectangular planes; the tube being movable within an outer collar so that it can be set at any depth and be thus lodged in the very centre of the windpipe. If the accident occur long after the operation, canulas of different lengths and curvature could be substituted from time to time so as to avoid constant pressure on points already irritated. In one case which I saw treated abroad, in which ulceration was supposed to exist, a long elastic catheter had been substituted for the canula with so much comfort that the little patient would not consent to the use of any other appliance.

Summing up the points discussed in the foregoing pages, we may, I think, with safety draw the following conclusions:—

1. That there are no insuperable contra-indications to tracheotomy in croup;

2. That the administration of an anæsthetic for the purpose of controlling the child's movements is admissible in performing the operation; but that it should be used with great caution;

3. That a careful dissection should be made down to the windpipe, and hemorrhage be arrested before incising it, whenever there is at all time to do so;

4. That the incision should be made into the trachea as near the cricoid cartilage as possible, to avoid excessive hemorrhage, and subsequent accidents which might occasion emphysema;

5. That a dilator should be used, or a piece of the trachea be excised, whenever any difficulty is encountered in introducing the tube;

6. That the tube should be dispensed with as soon as possible; or altogether if the case will admit of it;

7. That assiduous attention should be bestowed upon the after-treatment, especially that of the wound; and that a skilled attendant should be within a moment's call for the first twenty-four or forty-eight hours immediately following the operation.

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